St. Clair River

REMEDIAL ACTION PLAN

The St. Clair River Area of Concern

Environmental Conditions and Problem Definitions

STAGE 1

Remedial Action Plan
Plan d'Assainissement

Canada Ontario

DNR

Canada Ontario

January 10, 1992

The Honourable E. Davie Fulton
Chairman, Canadian Section
International Joint Commission
100 Metcalfe Street, 18th Floor
Ottawa, Ontario, Canada
K1P 5M1

Mr. Gordon K. Durnil
Chairman, United States Section
International Joint Commission
2001 S. Street, N.W., 2nd Floor
Washington D.C. 20440
U.S.A.

Dear Sirs:

The St. Clair River has been designated by Canada and the United States as an Area of Concern under the terms of the Great Lakes Water Quality Agreement (GLWQA, as amended by the Protocol of 1987). Annex 2 of the Agreement calls for the development of Remedial Action Plans for Areas of Concern and submission of documentation in three stages to the IJC.

Under the terms of a 1985 Letter of Intent signed by the Premier of Ontario and the Governor of Michigan, a Binational Remedial Action Plan is being jointly developed by a multi-agency RAP Team under the leadership of the Ontario Ministry of the Environment and the Michigan Department of Natural Resources. In Canada, the Board of Review for the Canada-Ontario Agreement Respecting Great Lakes Water Quality directs the federal-provincial Remedial Action Plan process. The plan is being developed with the active involvement of a Binational Public Advisory Council representing many sectors of society including the general public, local governments, interest groups and industry.

On behalf of participating agencies under the Canada-Ontario Agreement Respecting Great Lakes Water Quality, we are pleased to submit Stage One of the St. Clair River Remedial Action Plan. The document has been unanimously endorsed by the St. Clair RAP Binational Public Advisory Council and has been approved for submission by the COA Board of Review. It is our understanding that the Michigan Department of Natural Resources wishes to provide you with its own letter of transmittal.

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The binational Stage One RAP provides a description of environmental conditions and problems based on information available at the time of preparation. Results of more recent investigations and further consultation with the public will be reflected in the Stage Two submission.

Twenty-five copies of the Stage One RAP have been forwarded directly to the IJC Regional Office in Windsor. The RAP Coordinators from Ontario and Michigan would be pleased to make a presentation on this document to the Commission or its staff at your invitation.

for

Victor Shantora
Co-Chair, Canada
COA Board of Review

A/Regional Director General
Ontario Region
Environment Canada

Jim Ashman
Co-Chair, Ontario
COA Board of Review

Director
Water Resources Branch
Environment Ontario

St. Clair River
BLUEWATER BRIDGE
BINATIONAL PUBLIC ADVISORY COUNCIL

December 20, 1991

The Honourable E.D. Fulton
Chairman, Canadian Section
International Joint Commission

Mr. Gorden K. Durnil
Chairman, U.S. Section
International Joint Commission

The Honourable Ruth Grier
Minister, Ontario Ministry
of the Environment

Mr. Roland Harmes, Director
Michigan Department of
Natural Resources

Dear Madame/Sirs:

On behalf of the St. Clair River Binational Public Advisory Council (BPAC), we the Co-Chairmen express the BPAC's unanimous support for the St. Clair River Stage 1 Remedial Action Plan (RAP). We also have the following general comments to offer.

The St. Clair River BPAC is composed of 44 members coming from a variety of sectors from Canada and the U.S.: Health, Municipal, Native Peoples, Agriculture, Environment, Recreation, Industry, among others. This group of dedicated volunteers has been meeting for 3 1/2 years; approximately 8 times a year. In addition, there have been numerous subcommittee meetings and public meetings.

The St. Clair River BPAC has helped to gain public comment and provided advice to the RAP Team on various aspects of the RAP. All St. Clair River BPAC members have had an opportunity to share individual concerns, and all BPAC meetings are open to the general public, thereby providing other concerned citizens chances to address water quality issues.

Through the St. Clair River BPAC, and a variety of outreach activities, the local communities are more aware of the health of the St. Clair River and the impairments to be addressed.

A key benefit of the RAP planning process has been the St. Clair River BPAC's development into a cooperative working group. Each sector has gained an understanding that we share common goals. This type of forum has also given the membership a better appreciation of the tasks ahead and the potential impact clean-up efforts will create. This new perspective is a benefit to the community, and also to the agencies which will be implementing the RAP.

In supporting and endorsing the Stage 1 Remedial Action Plan, we bring to your attention the following issues raised in it:

- The RAP's planning and development process has taken too long. The St. Clair River BPAC encourages the International Joint Commission to expedite its review of the document and to send a strong message to the parties and agencies to complete Stage 2 in a more expeditious manner.

- Data presented in Stage 1 have also been a concern due to two reasons: In some cases more current data than that included in the document has been recently collected such as point source, sediment and sport fish data, but had not been available to the RAP Team prior to public review; for other key issues, data such as tributary, stormwater or CSO loadings data, human health data, and basin-wide standards for the protection of fish and wildlife, either do not exist or are not sufficient to adequately address the impairment status for some beneficial uses.

It is hoped that as Stage 2 progresses, these concerns previously outlined will be addressed. Having carefully reviewed the document, the St. Clair River BPAC offers its unanimous endorsement to the St. Clair River Stage 1 Remedial Action Plan.

Yours truly,
St. Clair River Binational Public Advisory Council

Timothy J. Lozen
U.S. BPAC
Co-Chairman

Don Poore
Canadian BPAC
Co-Chairman

c.c. D.A. McTavish/J.F. Janse - OMOE
P. Zugger/Rich Powers - MDNR
Maureen Looby - OMOE
Diana Klemans - MDNR

The St. Clair River Area of Concern

Environmental Conditions and Problem Definitions

Remedial Action Plan
Stage 1

St. Clair River RAP Team

Submission to the International Joint Commission

December 20, 1991

Ontario Ministry of the Environment, Detroit / St. Clair / St. Marys River Project
242A Indian Road, South, Room 203, Sarnia, Ontario N7T 3W4

Michigan Department of Natural Resources, Surface Water Quality Division
Great Lakes and Environmental Assessment Section, P.O. Box 30028
Lansing, Michigan 48909

Remedial Action Plan
Plan d'Assainissement

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DNR

FOREWORD

This document provides a summary of the environmental conditions in the St. Clair River Area of Concern (AOC) in Ontario and Michigan. It represents the Stage 1 submission of the St. Clair River Remedial Action Plan (RAP), in accordance with the Canada-U.S. Great Lakes Water Quality Agreement and the Canada-Ontario Agreement respecting Great Lakes Water Quality. It identifies specific environmental problems and identifies many of the sources of contaminants which may contribute to impairments of beneficial uses.

The report contains an executive summary which is presented as Chapter 1. Impairments to beneficial uses are identified and described in Tables 1.1 and 7.1. The identification of impairments is based on water, sediment and biota surveys which were carried out primarily in the 1985 to 1986 period including some available data as recent as 1990. The status of each beneficial use category has been assigned by the St. Clair River RAP Team, in consultation with the Binational Public Advisory Council, using the Listing and Delisting Guidelines prepared by the International Joint Commission in conjunction with applicable standards, guidelines and objectives where available.

A total of 56 municipal and industrial point sources discharge to the St. Clair River and its tributaries. Several nonpoint sources of contaminants are also identified. Loadings data are presented for the major point and nonpoint sources. The most recent loadings data which have been utilized are based on sampling undertaken from 1984 to 1990 (nonpoint sources) and between 1986 and 1989 (point sources). Recent (1988 and 1989) data for those parameters which are regularly monitored at all municipal and industrial facilities in Ontario and Michigan have been utilized. Data from Ontario's Municipal-Industrial Strategy for Abatement (MISA) monitoring studies of the petroleum sector conducted in 1988/89 have also been utilized.

Results of several recently completed or ongoing studies will be useful in updating the Stage 1 RAP but, as yet, are unavailable. These include:

- 1989/90 point source data for the organic chemicals, inorganic chemicals and thermal generating sectors collected under Ontario's MISA Program;
- bacteria loadings from Sarnia CSOs and WPCPs and nearshore bacteria densities along the Sarnia waterfront which is currently being analyzed by Environment Canada and OMOE;
- the final results for ambient data on water, sediment and biota quality which were collected throughout the river during 1990;
- the 1991 fish contaminant monitoring data collected by OMOE and MDNR; and
- the results of the ongoing Health and Welfare Canada Great Lakes Health Effects Cohort Study of anglers and Native populations within the AOC.

A number of data gaps have also been highlighted. These include:

- additional information on ambient conditions within the AOC with which to make definitive conclusions regarding the impairment status for the tainting of fish and wildlife flavour, dynamics of wildlife populations, and fish tumours and other deformities;
- wildlife consumption guidelines for the protection of human health with consideration of potentially sensitive populations that rely on the consumption of wild meat;
- Great Lakes Basin wide assessments of the effects of contaminant body burdens on fish, wildlife and benthic organisms;
- loadings from Michigan tributaries, CSOs and stormwater; and
- more complete upstream loadings data for several parameters.

The results of the 1990 ambient water, sediment and biota surveys, the bacteria survey, and the more recent point source loadings collected under Ontario's MISA Program will be reported as updates to Stage 1 as an initial component of the Stage 2 process. The Stage 2 Rap process will also identify and prioritize site-specific studies required to fill other data gaps.

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1.1 INTRODUCTION

The St. Clair River was listed in 1985 by the International Joint Commission (IJC) as one of 42 Areas of Concern (AOC) in the Great Lakes Basin. Areas of Concern were identified based on known water quality problems. A letter of intent was signed in December, 1985 by the Premier of Ontario and the Governor of Michigan, establishing a joint RAP process and providing for Ontario to take the lead role for the St. Clair River AOC. This agreement facilitated the development of a Binational Remedial Action Plan (RAP) Committee, or RAP Team, in 1987 comprised of federal, state and provincial representatives.

The RAP Team has been charged with development of a Remedial Action Plan for the St. Clair River, which is a staged process. This document represents the combination of efforts in development of Stage 1, in order to address the following requirements:

- detail existing environmental conditions in order that environmental problems in the St. Clair River may be defined and described;

- identify beneficial uses that are impaired, the degree of impairment and the geographical extent of impairment within the Area of Concern; and

- determine the causes of impairment, providing an assessment of all known sources of pollutants of concern and a description of other potential sources.

In addition to the technical document to address the above, an extensive public participation program has been developed in order to inform the public, improve the plan by gaining information and advice from the public, gain support for plan implementation, and provide a mechanism for accountability to the public.

A number of initiatives were undertaken to raise the profile of the RAP process among the general public through outreach activities, and a focused effort was placed upon the establishment of a Binational Public Advisory Council (BPAC) which could work with and advise the RAP Team on a regular basis during development of the RAP. The BPAC was created during early 1988. Its specific roles are to enable the RAP Team to be informed on public opinion and views regarding goals for the RAP and to advise the RAP Team on problem identification, planning methodology, public involvement, technical information, identification of available remedial options, selection of remedial actions and plan recommendations.

The BPAC consists of approximately 48 members from both Ontario and Michigan, representing a cross-section of communities on both sides of the river. Members of the BPAC have demonstrated extensive interest and knowledge in development of the RAP, and have provided active and informed input throughout the process. In October 1988, four members of the BPAC were elected as delegates to the RAP Team to facilitate communication between the RAP Team and BPAC.

Agency members of the RAP Team are able to provide technical expertise, either directly or through communications with experts within each of their organizations. While the Ontario Ministry of the Environment has been charged with the lead responsibility for development of the RAP, the Michigan Department of Natural Resources co-chairs the RAP Team, with additional members representing agencies including the Ontario Ministry of Natural Resources, Environment Canada, Fisheries and Oceans Canada, and the U.S. Environmental Protection Agency.

1.2 THE RAP PROCESS

The mechanisms for a cooperative binational venture such as a Remedial Action Plan for the St. Clair River, have been established through the development of the Great Lakes Water Quality Agreement (GLWQA). This agreement first signed by Canadian and U.S. governments in 1972, was revised in 1978 and subsequently amended in 1987. The amending protocol in 1987 included an annex which required Canadian and U.S. governments to develop and implement Remedial Action Plans for each of the Great Lakes Areas of Concern. As outlined in the 1987 GLWQA, an Area of Concern is defined as "a geographic area that fails to meet the General or Specific Objectives of the Agreement where such failure has caused, or is likely to cause impairment of beneficial use or the areas ability to support aquatic life". Fourteen use impairments are specified in the GLWQA including the following:

- i. Restriction on Fish and Wildlife Consumption;
- ii. Tainting of Fish and Wildlife Flavour;
- iii. Degradation of Fish and Wildlife Populations;
- iv. Fish Tumours or other Deformities;
- v. Bird or Animal Deformities or Reproductive Problems;
- vi. Degradation of Benthos;
- vii. Restrictions on Dredging Activities;
- viii. Eutrophication or Undesirable Algae;
- ix. Restrictions on Drinking Water Consumption, or Taste and Odour Problems;
- x. Beach Closings;
- xi. Degradation of Aesthetics;
- xii. Added Cost to Agriculture or Industry;
- xiii. Degradation of Phytoplankton and Zooplankton Populations; and
- xiv. Loss of Fish and Wildlife Habitat.

The existence of any one of the use impairments could be sufficient to list an area as an Area of Concern. Using this list as a basis, the IJC has solicited input in development and refinement of Listing/Delisting Criteria for Great Lakes' AOCs. In some cases, even with specific criteria outlined, it is difficult to definitively establish whether a beneficial use is impaired. As a consequence, the RAP Team has been required to exercise prudence and extensive consultation with both technical experts within and outside the RAP Team, as well as the BPAC. The St. Clair River Remedial Action Plan has used available environmental quality data to compare with the IJC Listing Criteria, in order to determine the impairment status of beneficial uses in the St. Clair River. In addition, exceedences of existing water quality criteria or effluent requirements, have been highlighted even though a direct relationship with an impairment of beneficial uses may not have been demonstrated. The public (both individuals and organizations) and various levels and types of government agencies were included throughout the Stage 1 RAP development process in an attempt to reach consensus on the problems in the St. Clair River.

Annex 2 of the 1987 protocol amending the GLWQA specifies that the RAP should be submitted to the IJC for review and comment at 3 stages. This document represents a completed Stage 1 outlining the definition and description of environmental problems, causes of these use impairments, a description of all known sources of pollutants involved, and an evaluation of other possible sources.

Stage 2 will define the specific goals for the Area of Concern and will describe the remedial and regulatory measures selected to achieve these goals. The Stage 2 RAP will include:

1. an evaluation of remedial measures in place;
2. an evaluation of alternative additional measures to restore beneficial uses;
3. a selection of additional remedial measures to restore beneficial uses and a schedule for their implementation;

4. an identification of the persons, agencies, or organizations responsible for implementation of the selected remedial measures;
5. a process for evaluating the implementation and effectiveness of remedial measures; and
6. a description of surveillance and monitoring process to track the effectiveness of remedial measures, and the eventual confirmation of the restoration of the uses.

Stage 3 of the St. Clair River RAP will be submitted when beneficial uses are restored. This stage of the RAP will include documentation that the beneficial uses are restored as measured through implementation of the monitoring program.

1.3 REGULATORY PROGRAMS

Numerous programs, regulations, objectives, guidelines and agreements to maintain and enhance environmental quality are in place and/or under development in Ontario, Michigan and at the federal levels in both Canada and the United States. The Stage 1 RAP identifies the current regulatory tools available to each jurisdiction and the control mechanisms currently in place and under development. An evaluation of this information as it pertains to the St. Clair River AOC will be undertaken as part of the Stage 2 RAP.

1.4 DESCRIPTION OF THE STUDY AREA

The boundaries of the Area of Concern include the entire river from the Blue Water Bridge (connecting Sarnia and Port Huron) to the southern tip of Seaway Island, west to St. John's Marsh and east to include the north shore of Mitchell's Bay on Lake St. Clair (Figure 1.1).

The St. Clair River forms the upper-most portion of the corridor between Lakes Huron and Erie serving as a 'connecting channel' from Lake Huron to Lake St. Clair. The river flows approximately 64 km (40 mi) in a southerly direction from the outflow of Lake Huron to Lake St. Clair. Prior to entering Lake St. Clair, the river divides into several channels creating an extensive delta known as the St. Clair delta (also referred to as the St. Clair Flats). The river velocity ranges from 1.67 m/s (5.48 ft/s) at the northern extremity to 0.31 m/s (1.02 ft/s) at Lake St. Clair. The river's width varies between approximately 250 and 1,200 m (820 and 3,940 ft) with river flows ranging from a winter low of 4,200 m^3/s and a summer high of 5,500 m^3/s (0.148 to 0.194 X 10^6 cfs). The average monthly discharge rate from 1900 to 1981 was 5,121 m^3/s (0.181 X 10^6 cfs).

A number of tributaries including the Murphy Drain, Talfourd, Baby and Bowens Creeks in Ontario and the Black, Pine and Belle Rivers in Michigan drain into the St. Clair River. Tributary watersheds in Ontario represent an area of 20,976 ha (51,810 acres) of which Talfourd Creek comprises 20,800 ha (51,400 acres). The total watershed area of all the Michigan tributaries is 315,900 ha (780,600 acres).

Several islands have been created by the division of the river into numerous channels in the St. Clair delta area (Figure 1.1). Walpole Island consists of 6 separate islands, all of which are separated by a series of channels. Seaway Island lies between the South Channel and the St. Clair Cutoff, and Basset Island is between the St. Clair Cutoff and Basset Channel. Collectively, these islands along with Squirrel, Walpole, Pottowatamie and St. Anne Islands form the Walpole Island Indian Reserve on the Canadian side of the International Border. On the U.S. side, Dickinson Island is located between the North Channel and the Middle Channel, and Harsens Island lies between the Middle and South Channel.

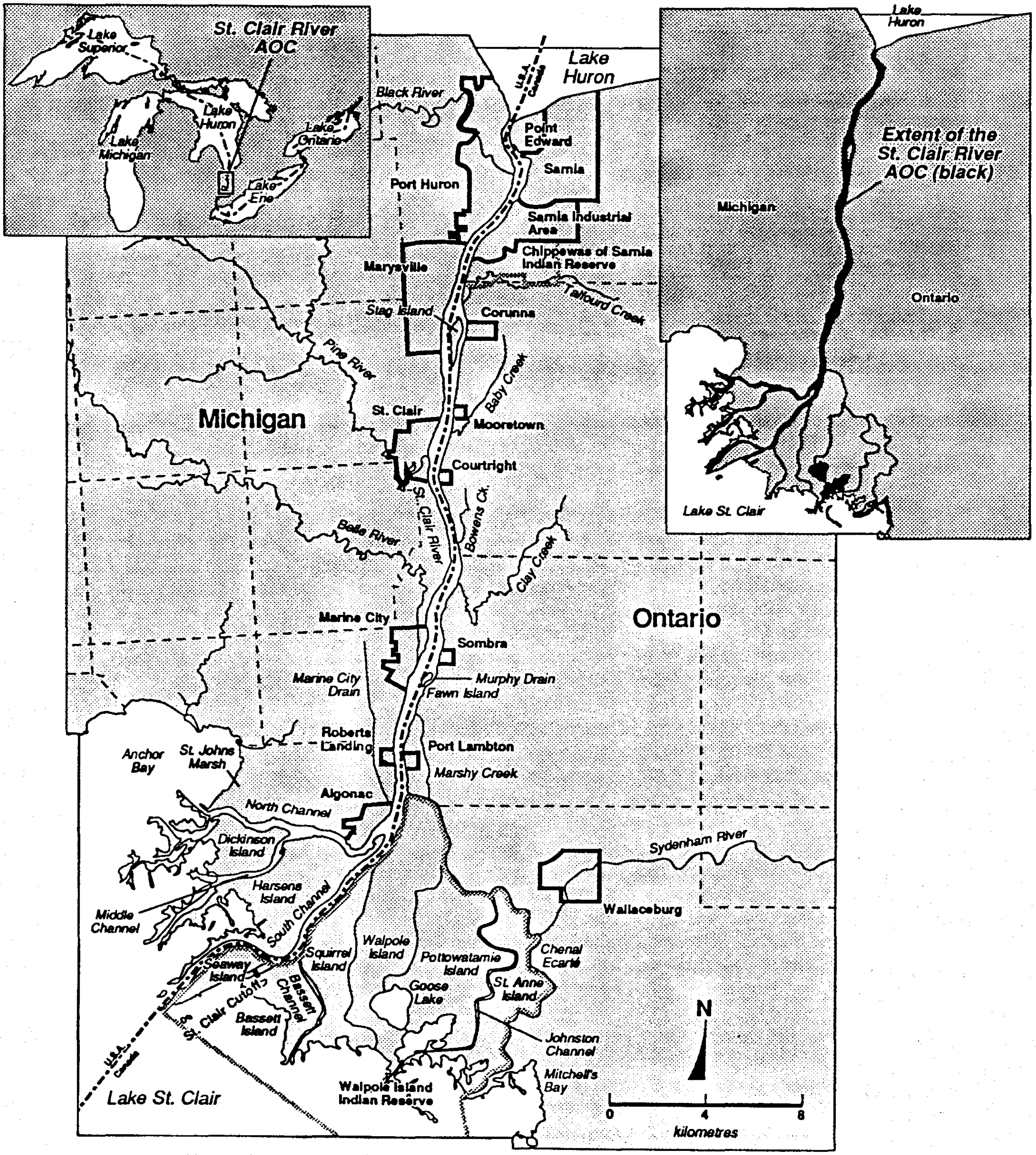
The St. Clair River lies on the eastern rim of the Michigan Basin typified by consolidated sedimentary rocks of Paleozoic origin, overlain by glacial and post glacial lake deposits. The channel of the St. Clair River is cut through hard stony glacial clay till in its centre, and a fine silt clay till in the nearshore area. The hard till substrate of the river is resistant to erosion accounting for the river's straightness and high water clarity. The sediments of the St. Clair delta are derived from silts and sands eroded from the shores of Lake Huron. These soils are comprised mainly of fine sandy loams.

Figure 1.1

St. Clair River Remedial Action Plan

Location map of the St. Clair River area of concern (AOC)

(after UGLCCS 1988)



---- township boundary

—— municipal boundary

~~~~ Indian reserve boundary
~~~~

There are two primary terrestrial biological zones located adjacent to the main river. These include: (1) the upland hardwood forests, mostly located on the banks of the river and along its tributaries; and (2) a diverse species assemblage in areas which are transitional to the river and its wetlands. Wetlands are particularly prominent in the area of the delta. The transitional zone can be divided into four main species assemblages including shrub ecotones, wet meadows, sedge marshes and island shorelines and beaches. A large portion of the original hardwood forests have been cleared for agricultural, industrial or urban development.

Submergent and emergent macrophytes are the main primary producers in the St. Clair system, as well as providing cover and food for fish, waterfowl and invertebrates. There are four main types of aquatic plant communities in the St. Clair River and delta including open water communities, river channel communities, cattail marshes and abandoned river channel communities.

Aquatic life within the river is also diverse, consisting of phytoplankton, zooplankton, benthic fauna, and numerous fish species. Phytoplankton composition is dominated by diatoms. The zooplankton community is dominated by fugitive drift species carried into the river from Lake Huron. At least 179 benthic faunal species are known to occur in the St. Clair River. The most common benthic invertebrates represent the Nematoda, Oligochaeta, Amphipoda, Diptera, Ephemeroptera, Trichoptera, Gastropoda and Pelecypoda orders. There are at least 91 species of fish including both residents and migrants.

1.4.1 Land Use

Land uses adjacent to the St. Clair River are in large part comprised of the following: agriculture, urban, rural, industrial, native lands, recreation, forests and wetlands, and waste disposal.

In Ontario, 78 percent of immediate St. Clair drainage area is dedicated to agricultural applications including cash cropping, beef and swine operations. In Michigan, 68 percent of the area draining into the St. Clair River is dedicated to agricultural purposes, with cash cropping, beef and dairy operations accounting for the majority of this activity.

Approximately 170,000 people live on or near the shores of the St. Clair River, with about 90,000 on the Canadian side and 80,000 on the U.S. side. While much of this population is centred in the cities of Sarnia, Ontario and Port Huron, Michigan, a significant portion live in rural areas.

Most of the areas' industry is concentrated within the industrial area between Sarnia and Corunna in Ontario, although industrial facilities occur downstream of Corunna as well as on the Michigan side of the AOC. The presence of the St. Clair River and the local geology are the primary reasons for the concentration of industry in this area. Industrial facilities along the river include petroleum refineries, organic and inorganic chemical manufacturers, paper companies, salt producers and thermal electric generation facilities.

Two Native Indian reserves situated along the Canadian shore of the St. Clair River include the Chippewa of Sarnia Band Reserve and the Walpole Island First Nations Indian Reserve (Figure 1.1). Band members in the Walpole Reserve operate a community farm, localized industry and also rely on hunting, fishing and trapping for food and income.

An extensive park network provides substantial recreational amenities along both shores of the St. Clair River. These include campgrounds, day use parks, marinas and a limited number of beaches.

A relatively small portion of the land bordering on the St. Clair River is forested. Eight coastal wetland areas are situated along the St. Clair River and an additional seven are situated within the delta. An estimated 3,380 hectares (8,350 acres) of emergent aquatic plants occur primarily in the lower portion of the St. Clair River.

There are also a total of 21 industrial and two municipal waste sites and landfills in Ontario located within close proximity to the river. The majority of the industrial waste disposal and landfill sites are located near the head of the river where groundwater seepage rates tend to be highest. In Michigan, there are six sites of environmental contamination within 4.8 km (3 mi) of the St. Clair River which are listed on the Priority List for Evaluation and Interim Response under Act 307.

Numerous deep well injection sites are situated on both sides of the St. Clair River. Seventy-two injection wells, including 63 currently in operation, are located on the Michigan side of the St. Clair River. There are no injection wells where hazardous waste is injected into or above underground sources of drinking water. In Ontario, deep injection wells were used to dispose of industrial wastes, cavern brines and oil field brines between 1958 and 1972. Of the 35 deep injection wells originally operated, approximately 20 wells are currently utilized for the disposal of cavern brine and oil field brine.

1.4.2 Water Resource Use

Water resource uses on the St. Clair River are numerous and include: shipping, water supply, fish and wildlife habitat, commercial fishing, sport fishing, hunting and trapping, native consumptive resource utilization, swimming and recreational boating, naturalist uses and effluent receiver. The St. Clair River is part of the Great Lakes Seaway conveying commodities such as coal and lignite from lower Great Lakes ports or ocean ports and iron ore, limestone and grain from ports in the upper Great Lakes. A minimum depth of 8.2 m (27 feet) is required for shipping on the river necessitating periodic dredging of sediments, particularly in the lower channels. Dredged material removed for navigational purposes is disposed of in confined disposal facilities or in open waters, contingent upon contaminant levels which are monitored in representative samples.

Approximately 2.7 percent of the river's average flow is utilized for in-plant process operations and once-through, non-contact cooling water by industrial facilities along the length of the river. Most of the cooling water which is drawn from the river (80 percent) is utilized by thermal generating stations. The treated water supply for Sarnia and Port Huron is provided from intakes in lower Lake Huron, however, a number of downriver communities currently rely on St. Clair River water for drinking purposes.

The St. Clair River provides diverse and extensive fish and wildlife habitat. At least 91 species of fish have been recorded as resident or migrants in the river and its delta, with at least 46 species utilizing the area for spawning and nursery habitat. The coldwater fish community is largely composed of exotic species (rainbow and brown trout, chinook and coho salmon and rainbow smelt) which have filled the niche left absent by native species such as lake trout, lake whitefish and lake herring. Important members of the coolwater fish community are lake sturgeon, northern pike, muskellunge, walleye and yellow perch. The warmwater community includes longnose gar, bowfin, smallmouth bass, largemouth bass, white bass, channel catfish, suckers and several species of minnows and sunfishes.

The wetlands and associated open waters of the lower St. Clair River and Lake St. Clair is one of the most important wetland systems in the Great Lakes region for ducks, geese and swans. The Area of Concern provides habitat for at least 20 species of amphibians, 25 species of reptiles, 250 species of birds and 60 species of mammals.

During the early 1800s lake whitefish, lake herring, walleye and yellow perch formed the principle catch for the commercial fishery. A change in species composition has occurred over time, due in part to overfishing of more desirable species and habitat alterations. Catch records reflect the permanent closure of Michigan's commercial fishery in 1909 to all species except carp and in Ontario to the closure of the smallmouth bass commercial fishery, in response to increasing pressure from recreational fishermen. The commercial fishery in Lake St. Clair was closed for a 10 year period beginning in 1970, due to high mercury contamination.

Presently, commercial fishing within the St. Clair River itself is considered negligible. In contrast, bait fishing is an important industry on the Ontario side of the St. Clair River, spurred by the popularity of sport fishing.

Sport fishing has been a popular long-standing activity on the St. Clair River and its delta distributaries. No Ontario based intensive creel surveys have been undertaken on the river however, some records are available for Lake St. Clair. During 1977-1985, ice anglers fished an average of 33,140 angler days and harvested an average of 128,838 walleye, yellow perch and bluegills annually. Over the same period, summer anglers expended an average of 93,225 angler days and harvested an average of 193,382 walleye, yellow perch, smallmouth bass and muskellunge annually. In Michigan, the average annual fishing effort during 1983-1985 was 690,750 angler days in the St. Clair system (including the river, delta and Lake St. Clair). The average combined catch by boat, shore and ice anglers was 1,392,000 fish. This represented a value of approximately $7.6 million (U.S.) generated by the recreational fishery on an annual basis. In Ontario, the value of the sport fishery in 1989 was estimated to be $3.2 million (Cdn).

Hunting and trapping are significant uses of the St. Clair River Area of Concern. In Ontario and Michigan, waterfowl hunting and small game harvesting account for the bulk of these activities. The St. Clair River and the wetlands of the delta provide many of the waterfowl hunting opportunities available in Lambton and Kent Counties of Ontario.

Fishing, hunting and trapping are important activities to native people living on the St. Clair River, as they provide food, revenue and a continuance of traditional values. Considerable revenue is generated through harvesting of pelts, lease of reserve lands, guiding services and fishing and hunting licences. For example, prior to 1980 more than 100,000 muskrats were harvested annually. In 1987 the average price was $6.00 (Cdn) per pelt, however, the recent downturn in the fur industry reduced the 1989 harvest to only 10,000 pelts valued at $20,000 (Cdn).

The St. Clair River system, due to its ready accessability to many people in southwestern Ontario and southeastern Michigan, is a significantly utilized recreational waterbody. Swimming, boating, as well as naturalist activities are some examples of recreational uses of the St. Clair River.

There are 56 point sources discharging into the St. Clair River and its tributaries from Michigan and Ontario. These include thermal electric generating stations; industrial facilities representing the organic chemicals, inorganic chemicals, petroleum refining, pulp and paper, and food processing sectors; and municipal wastewater treatment plants. Total point source flows from all facilities are approximately $11,800 \times 10^3$ m^3/day ($3,068 \times 10^6$ U.S. gal/day).

A large number of the petrochemical facilities located in the industrial area in and south of Sarnia ('Chemical Valley') were constructed during the early 1940s in support of the war effort. The Sarnia area was selected during this period and historically because of its proximity to the St. Clair River, as well as the presence of local underground sodium chloride (salt) deposits, both prerequisites for manufacturing chlorinated organic chemicals.

Refineries in the area manufacture such products including:

- gasoline, diesel, jet fuel;
- petrochemical feed stocks;
- lubricating oils and waxes;
- aromatic solvents;
- petrochemicals; and
- fuel coal products.

Chemical manufacturing facilities produce a wide array of products including the following:

- polyethylene resins;
- solvents;
- polyvinyl chloride resins;
- polypropylene;
- styrene monomer;
- rubber latex and synthetic rubber; and
- fertilizers and many other products.

In addition to the Ontario and Michigan industrial and municipal point sources are numerous Combined Sewer Overflow (CSO) discharges which combine urban runoff with partially treated sewage during high precipitation events. CSOs are located in Sarnia, Port Huron and a few smaller communities.

Nonpoint sources of contaminants to the St. Clair River AOC include atmospheric deposition onto the watershed, urban and rural runoff, the resuspension of contaminated sediments, groundwater, and spills from ships, industries and other facilities.

1.5 ENVIRONMENTAL CONDITIONS

1.5.1 Habitat Loss and Wildlife Populations

Losses of the aquatic plant community have occurred due to industrial, agricultural, recreational and urban developments. Many of the wetlands of the St. Clair system have been lost, primarily because of drainage of large tracts of land for agriculture. Considerable wetland acreage was also lost due to dredging or filling related to navigation, marina and housing developments. In addition, many wetlands have been seriously impaired by dykes that hydrologically separate them from the main channel.

Between 1873 and 1973 wetland losses of 72 percent (5,252 ha/12,972 acres) occurred on the Michigan side of Lake St. Clair. The Ontario wetlands, from the Thames River mouth in Lake St. Clair north to Chenal Ecarte, dwindled from 3,574 ha (8,830 acres) in 1965 to 2,510 ha (6,200 acres) in 1984. These include losses within the AOC along channels of the Walpole Island Indian Reserve. Drainage for agriculture accounted for 92 percent of the losses and the remainder was due to marina and cottage development.

In addition to habitat losses documented for the delta, there have been extensive alterations to the shoreline and inland areas upstream of the delta. These losses are due to industrial, agricultural and urban development throughout the watershed of the AOC. Extensive bulkheading and infilling has occurred along much of the river resulting in the loss of spawning, rearing and feeding sites for many fish species.

Estimated peak numbers of waterfowl were approximately 150,000 in the Ontario portion of the delta during the autumn. Use of this area during the autumn has shown an overall increase of 37 percent between 1968-1982, however, there has been a 14 percent decline in the use of this area by diving ducks during the fall. Spring use of this area has shown little change between 1968 and 1982 in terms of the estimated peak number of waterfowl (60,000 birds), however, use of the area by dabbling ducks, such as American widgeon, green-winged teal, blue-winged teal and wood ducks, decreased by 79 percent between 1968 and 1982.

1.5.2 Water Quality

Results of water surveys in the St. Clair River reveal that the most contaminated portion of the river, as identified by concentrations which are elevated above those at the head of the river or laterally across the river, by conductivity, and by water quality guideline exceedences, is governed by the flow pattern of the river. The majority of the contaminants in the St. Clair River waters originate in the industrial area south of Sarnia. A contaminant plume tends to hug the Canadian shoreline from the Cole Drain and gradually enlarges downstream where it extends up to 300 m (984 ft) from the Canadian shore at Port Lambton. The flow pattern of the river funnels the plume into the Chenal Ecarte and South Channel of the delta.

Exceedences of Objectives, Guidelines and Standards

Contaminants which have exceeded, Canadian Guidelines, Great Lakes Water Quality Agreement (GLWQA) Objectives and/or Provincial Water Quality Objectives (PWQO) include, fecal coliform bacteria, cadmium, copper, iron, zinc, hexachlorobutadiene, hexachlorobenzene and octachlorostyrene. The discharge of inadequately treated sewage from Michigan CSOs during runoff events have also causes impairments downstream of the outfalls. Michigan Water Quality Standards (WQS) were exceeded for fecal coliform bacteria, chloride, cadmium, copper, lead, mercury, zinc, dieldrin, total PCBs, hexachlorobenzene, tetrachloroethylene and carbon tetrachloride. In addition, the periodic discharge of inadequately treated sewage from Michigan CSOs imports downstream areas.

Copper exceeded the PWQO and GLWQA Objective by up to 4 times (average) and the Michigan WQS, Rule 57 Value by up to 2 times at the Lambton (Sarnia area) and Walpole Island water intakes in 1988. The source of the copper to the Lambton WTP, which draws its water from Lake Huron, is unknown but is clearly upstream of the AOC. Iron exceeded the PWQ and GLWQA Objectives, however, the pattern of contamination does not indicate likely sources within the AOC.

The Provincial Water Quality Guideline for phosphorus was occasionally exceeded prior to 1986, however, the ambient concentrations in 1986 and 1988 were generally well below the guideline. Ammonia exceeded the PWQO within the industrial area in 1977, however, recent data collected at the water treatment plant intakes suggest that this parameter is below objectives for the protection of aquatic life. Chloride concentrations are elevated in the contaminant plume on the Ontario side with 1986 concentrations increasing by more than an order of magnitude from upstream of the Sarnia industrial complex to immediately offshore of the industrial area. There is no PWQO for chloride, however, increasing concentrations both downstream and during the period from 1985 to 1988 are of concern. Also, the maximum chloride concentration adjacent to the Ontario industrial waterfront exceeded the Michigan Surface WQS during 1986.

Hexachlorobenzene in the area immediately downstream of the Cole Drain exceeded the PWQO and the Michigan Surface WQS, Rule 57 Value (January 1991). Hexachlorobenzene concentrations in water exceeding these guidelines, measured from 1984 through 1986, originated downstream of the Cole Drain and remained as exceedences up to the head of Stag Island near Corunna. Octachlorostyrene concentrations were found to exceed the Ontario Ministry of the Environment interim advisory from downstream of the Cole Drain, Dow and Suncor outfalls, and down-river within 100 m (328 ft) of the Canadian shoreline at Port Lambton and in the delta channels, Chenal Ecarte and South Channel during 1985 and 1986. Hexachlorobutadiene concentrations exceeded the Canadian Water Quality Guideline for the protection of aquatic life downstream of the Cole Drain and Dow 1st Street Sewer complex. Total PCB concentrations in whole water during 1985 exceeded the Michigan Surface WQS, Rule 57 Value (January 1991)(0.00002 μg/L) at 11 stations located throughout the river. These included stations located at both the head and mouth of the river and no pattern relating to sources within the AOC could be identified.

Parameters Elevated Above Background Concentrations

Other parameters found in the plume along the Ontario shore at concentrations which were elevated above those upstream of the plume (head of river or Lake Huron) in 1986, but either did not exceed guidelines or for which no guidelines are available, include hexachloroethane, pentachlorobenzene, 1,1,1-trichloroethane and chloroform. Minor organics exhibiting elevated levels during 1986 in the Sarnia area are methylene chloride, bromodichloromethane and dibromomethane. Although not exceeding guidelines, these parameters have been listed by OMOE on the Effluent Monitoring Priority List (EMPPL) which identifies those contaminants of greatest concern due to combined exposure and effects concerns.

Concentrations of tetrachloroethylene and carbon tetrachloride were found in the St. Clair delta channels, particularly in South Channel, and at the mouths of South Channel, Bassett Channel and Chenal Ecarte in concentrations which were elevated relative to those in central Lake St. Clair during 1984. Higher concentrations of both parameters in the South Channel relative to the North Channel or in Lake St. Clair suggest a contaminant plume which originates along the Ontario side of the St. Clair River.

Hexachlorobutadiene, hexachlorobenzene and octachlorostyrene in Talfourd and Bowens Creeks and the Pine River (Michigan) occurred at concentrations elevated above those typically found at the head of the St. Clair River, suggesting that these tributaries may also serve a sources of contaminants.

Historical Trends

Levels of mercury in the St. Clair river waters have been reduced by up to two orders of magnitude between 1973 and 1988:

- in 1973, mercury concentrations in water were 4.6 and 2.4 $\mu g/L$ at the head and mouth of the river respectively;
- in 1984, whole water samples had mercury concentrations at or below detection (0.01 $\mu g/L$) for most of the river with locally elevated maximum concentrations averaging 0.1 $\mu g/L$ offshore of the Sarnia industrial area and Chenal Ecarte respectively;
- in 1986, whole water samples were also generally at or below detection (0.01 $\mu g/L$) throughout the river with maximum concentrations reduced to 0.03 $\mu g/L$; and
- in 1988, whole water samples with annual means of 0.03, 0.02 and 0.01 $\mu g/L$ at the intakes for the Lambton, Walpole Island and Wallaceburg Water Treatment Plants.

Although much reduced, these 1988 mean concentrations of total mercury were higher than the Michigan Rule 57(2) value (January 1991) for methylmercury (0.0013 $\mu g/L$).

The average and maximum concentrations of hexachlorobenzene downstream of Dow's 1st St. Sewer complex were lower in 1985 and 1986 than 1984. However, due to a lack of historical data for industrial chlorinated organics, it is not possible to identify long-term trends in hexachlorobenzene for the St. Clair River.

1.5.3 Bottom Sediment Quality

Results of bottom sediment surveys in the St. Clair River reveal the most heavily contaminated portion of the river, as identified by the most frequent exceedences of dredged material disposal guidelines, by relatively high concentrations and by sediment toxicity, is the area within 100 m (328 ft) of the Ontario shore from the Cole Drain to downstream of Suncor.

Sediment Guideline Exceedences

Contaminants in bottom sediments sampled between 1977 and 1986 located along the Ontario shore of the St. Clair River and in some tributary mouths which exceed the Ontario Ministry of the Environment's guidelines for the open water disposal of dredged material are total Kjeldahl nitrogen, total phosphorus, arsenic, mercury, cadmium, copper, chromium, iron, lead, nickel, zinc, oil and grease, and PCBs. Concentrations of oil and grease, arsenic, copper, iron, manganese and mercury are classified as heavily polluted by the U.S. EPA interim guidelines for the disposal of Great Lakes harbour sediments whereas chromium and nickel are moderately polluted based on samples obtained from 1983 to 1986.

Hexachlorobenzene and total PAHs exceeded the lowest effect level of Ontario's proposed biologically-based sediment quality guidelines. Most exceedences occurred along the Sarnia industrial waterfront, as far downstream as the Lambton Generating Station, and at the mouths of Talfourd Creek, Baby Creek and the Murphy Drain.

Sediments on the Michigan side of the river are generally much less polluted than those on the Ontario side. Mean concentrations of copper and iron from 23 stations sampled in 1985 along the Michigan shore exceed the Ontario open water disposal of dredged material guidelines. The mean copper concentration is also classified as moderately polluted by the EPA interim guidelines for the disposal of Great Lakes harbour sediments. Two sites immediately downstream of the CN tunnel had concentrations of lead which exceed the Ontario disposal guideline and are classified as heavily polluted by the U.S. EPA interim guideline. Maximum iron concentrations in sediment along the Michigan side of the river are also classified as heavily polluted. Sediments in the lower river, downstream of the mouth of the Pine River, exceeded OMOE guidelines for arsenic, chromium, iron and nickel and were classified as heavily polluted by the U.S. EPA guidelines for arsenic, iron and manganese during 1983. Oil and grease concentrations in sediment of the North Channel, adjacent to Port Huron and adjacent to Marine City were classified as moderately polluted by the EPA interim guidelines.

Elevated Concentrations of Parameters in Sediments

Other parameters measured up to 1986 found in sediments at high concentrations, relative to sediments upstream of the Sarnia industrial area, but either not exceeding guidelines or for which no guidelines are available include zinc, oil and grease, phenanthrene, hexachlorobutadiene, octachlorostyrene, tri-, tetra- and pentachlorobenzene, hexachloroethane, tetrachloroethylene, carbon tetrachloride, tetrachloroethanes, pentachloroethane, chlorobutenes, heptachlorostyrene, octachloronapthalene, alkanes, diphenylether, biphenyl, 4-ethylbiphenyl and diethyl biphenyl, dibenzofurans and dibenzo-p-dioxins. In most cases there are no sediment quality guidelines for these parameters, however, they have been listed by OMOE on the Effluent Monitoring Priority List (EMPPL) which identifies those contaminants of greatest concern due to combined exposure and effects concerns.

Organic contaminants found in sediments on the Michigan side of the river included hexachlorobutadiene, hexachlorobenzene and octachlorostyrene. Concentrations of these parameters in sediments immediately downstream of the mouth of the Black River were elevated above those from the St. Clair River upstream of the mouth of the Black River. These three parameters also occurred at concentrations in sediment during 1984 which were elevated relative to upstream stations in the vicinity of the Marysville WWTP.

Historical Trends in Sediment Contamination

Sediment cores from the St. Clair River downstream of the Dow 1st Street outfall show a pattern of declining concentrations of PAHs, mercury and oil and grease up to 1985. Mercury concentrations in surficial sediments offshore of Dow, for example, have declined from a high of 90 $\mu g/g$ since the early 1970s to 52 $\mu g/g$ in 1986. Similarly, maximum lead concentrations in sediment downstream of the Ethyl Corporation outfall have declined from 640 $\mu g/g$ in 1983 to 330 $\mu g/g$ in 1985. Oil and grease concentrations downstream of Esso Petroleum have declined from maximum values of 28,000 $\mu g/g$ in 1977 to between 750 and 5,300 $\mu g/g$ in 1985 and 86 to 3,500 $\mu g/g$ during 1986. PCB concentration ranges in the river reach between Esso Petroleum and Suncor declined from 3 to 10 $\mu g/g$ in 1977 to 0.035 to 2.6 $\mu g/g$ in 1985 and below detection to 2.1 $\mu g/g$ in 1986. Although differences in analytical and sampling methodology may affect the results, there appears to be a trend of declining concentrations of mercury, lead, PCBs and oil and grease in bottom sediments of the St. Clair River.

In contrast, higher concentrations of hexachlorobenzene and octachlorostyrene in surficial layers of cores suggest continued high loadings, at least up to 1985.

1.5.4 Biota Quality

Benthic Macroinvertebrates

Studies of benthic invertebrate community structure from 1968 to 1985 indicate a strong pattern of improving environmental quality on the Canadian side of the St. Clair River. The U.S. side of the river had healthy benthic communities throughout this monitoring period. The implementation of industrial and municipal abatement programs since the early 1970s has resulted in the reclamation of 9 km (5.6 mi) of the Ontario portion of the river between 1977 and 1985. Further anticipated improvements in benthic structure will be tested by a repeat of the 1985 investigation which was carried out during 1990, however, the results are not yet available.

Data on heavy metals in benthic fauna suggest that lead and cadmium contamination of two species of mussel in the St. Clair River and downstream, are primarily the result of discharges from Canadian sources.

Inputs along the industrial complex south of Sarnia are considered to result in accumulations in the tissue of introduced mussels sampled in the period of 1982 to 1987 of octachlorostyrene; hexachlorobenzene; hexachlorobutadiene; pentachlorobenzene; PCBs; PAHs; chloroform; benzene; ethylbenzene; xylenes; 2,4,5-trichlorotoluene; 1,2,4-trichlorobenzene; 1,2,3,5-trichlorobenzene; 1,2,3,5-tetrachlorobenzene; and 1,2,4,5-tetrachlorobenzene. Inputs to the river between Talfourd Creek and Polysar in Corunna contributed 1,3,5-trichlorobenzene, pentachlorobenzene and 1,2,3,5-tetrachlorobenzene. Accumulations of lead in mussel tissue were found immediately offshore and downstream of the Ethyl Corporation discharge.

Mussel studies in the St. Clair delta undertaken in 1982 and 1987, however, suggest that body burdens of octachlorostyrene, pentachlorobenzene and hexachlorobenzene have decreased in this area.

Fish

Mercury, lead, octachlorostyrene, hexachlorobenzene and PCBs have been found in the flesh of sport and/or juvenile fish with concentration patterns indicating sources in the industrial complex south of Sarnia. Concentrations of mercury and PCBs measured in 1985 are sufficient in the larger size classes of walleye, white sucker, carp, yellow perch, freshwater drum and/or gizzard shad at certain locations to exceed consumption guidelines. The consumption guideline for lead had not been exceeded as of 1985.

The octachlorostyrene criterion for the protection of piscivorous wildlife established for Niagara River biota was exceeded by all annual means for catfish and carp in Lake St. Clair collected up to 1986 as well as in juvenile fish collected downstream of the industrial complex at Suncor and Lambton Generating Station up to 1987. The hexachlorobenzene criterion for the protection of piscivorous wildlife was not exceeded at any location for channel catfish, carp or juvenile fish.

Although not conclusive, analyses of spottail shiners between 1978 and 1987 indicate that concentrations of DDT, hexachlorobenzene, octachlorostyrene and PCBs have declined. Statistically significant reductions in fish tissue were found for PCBs and octachlorostyrene in fish collected during 1987 at the Lambton Generating Station compared to those collected in 1985 and 1986 at the same location. Total PCBs, however, have increased from 1987 to 1988 at this collection site.

Wildlife

Recent (1985-1988) data on organic chemical contaminant burdens in wildlife are available for certain mammalian and avifauna from the vicinity of the AOC, particularly the lower river and delta. However, there are no data on the impacts of these chemical burdens on wildlife health nor population dynamics nor on health effects of those people who consume these wildlife.

PCBs, octachlorostyrene, hexachlorobenzene, pentachlorobenzene and several chlorinated pesticides were found to accumulate in resident muskrats and turtles, as well as non-migratory ducks living within the AOC. Non-migratory redheads and mallards were found to have the highest concentrations of octachlorostyrene, particularly in liver tissue, as compared to other species of duck within the AOC. Herring gull eggs from colonies in the lower St. Clair River had 1.6 to 3.5 times the concentrations of hexachlorobenzene than eggs from colonies in the Detroit and Niagara Rivers and Lakes Superior, Erie and Ontario. Migratory goldeneye ducks also accumulated PCBs, DDE, octachlorostyrene, dieldrin, hexachlorobenzene and heptachlor epoxide over a three month period (December to February) while resident in the lower St. Clair River. Domestic, chemically clean ducks introduced to the St. Clair River delta were found to bioaccumulate octachlorostyrene, hexachlorobenzene and PCBs by up to five times within an approximately one month period (July-August).

1.6 ENVIRONMENTAL CONCERNS/USE IMPAIRMENT

Impairments to beneficial uses in the St. Clair River AOC were determined from the data presented on physical, chemical and biological environmental conditions. As a result, the GLWQA beneficial use categories were identified as impaired, not impaired or requiring further assessment. In the latter case, further assessment is required prior to concluding whether or not the use is impaired. For some beneficial uses this requires the development of concentration based guidelines for chemicals or species for which none are available. Such guidelines are not necessarily endemic to the St. Clair River AOC, but will require assessment of conditions within the entire Great Lakes ecosystem.

Table 1.1 summarizes the findings with regard to each use impairment as well as the parameters and locations for which ambient water quality criteria were exceeded. The status of each impairment is also identified. Use impairments in the St. Clair River AOC are: restrictions on fish consumption, bird and animal deformities, degradation of benthos, restrictions on dredging activities, restrictions on drinking water consumption, drinking water taste and odour problems, beach closings, degradation of aesthetics, added cost to agriculture and industry, and loss of fish and wildlife habitat. Beneficial uses determined not to be impaired include dynamics of fish populations, eutrophication or undesirable algae, and degradation of phytoplankton and zooplankton populations.

1.7 SOURCES OF CONTAMINANTS

Point sources contribute by far the largest loadings for the majority of contaminants entering the St. Clair River. However, the nonpoint source loadings should not be disregarded with respect to remedial strategies. Of particular concern are nonpoint source loadings of copper, iron, lead, mercury, nickel, cadmium, cobalt, PAHs, and PCBs. Nonpoint source loadings constitute more than ten percent of the total loadings for each of these parameters. In addition, nonpoint phosphorus and zinc contributions are close to ten percent of the total loadings. The actual contributions from nonpoint sources may be underestimated because data are not available from all nonpoint sources.

It should be noted there are shortcomings in the available data. For example, not all parameters have been analyzed from all sources, data have been collected during various time periods, different sampling techniques and detection limits were used and different methods for calculating loads (eg. point sources) were used. The absence of data does not preclude the potential presence of a contaminant in discharges.

Loadings of contaminants due to spills from Ontario and Michigan sources have also been identified. Because many spills represent large, short-term inputs, they can not be compared directly to ongoing loads discharged from point sources. This is because the pollutants in spills are often mixed with other chemicals and acute biological effects due to spills may be noted due to the large loadings contributed at one time rather than chronic or sublethal effects related to smaller loadings contributed over a long period of time.

Table 1.1 Summary of impairments to Great Lakes Water Quality Agreement beneficial uses within the St. Clair River AOC. Impairment status is defined as impaired (I), not impaired (NI) or requires further assessment on a site specific basis[1] (A) or on a Great Lakes Basin basis[2] (B) and is based on data collected over the period 1983 through 1990[3].

GLWQA Impairment of Beneficial Use	Status of Impairment	Conditions in the St. Clair River
RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION		
Restrictions on Fish Consumption	I	Fish consumption advisories currently in effect are: Ontario - mercury: walleye, white sucker, freshwater drum and yellow perch - PCBs: carp and gizzard shad Michigan - mercury and PCBs: freshwater drum, gizzard shad and carp
Consumption of Wildlife	B	There are currently no guidelines directly applicable to the St. Clair River AOC regarding human consumption of wildlife. However concentrations of PCBs in snapping turtles as well as octachlorostyrene, hexachlorobenzene and PCBs in mallards and redheads, which are utilized by human consumers such as residents of the Walpole Island First Nations Band, highlight the need for these guidelines. The Ontario Ministry of Natural Resources has issued a warning for people to use prudence with respect to the regular consumption of turtle meat from some areas including Walpole Island due to PCBs.
TAINTING OF FISH AND WILDLIFE FLAVOUR	A	There have been anecdotal reports of tainting.
DEGRADATION OF FISH AND WILDLIFE POPULATIONS		
Dynamics of Fish Populations	NI	The fish fauna of the St. Clair River are considered diverse and well-balanced.
Body burdens of fish	B	Several contaminants including mercury, PCBs, hexachlorobenzene and octachlorostyrene have been found in adult and juvenile fish on the Ontario side of the river and in the St. Clair Delta. Effects of these chemicals on fish are not known. Research on body burdens and associated effects in fish is required for the entire Great Lakes ecosystem.
Dynamics of Wildlife Populations	A	The use of the wetlands of the St. Clair Delta by true marsh-dwelling waterfowl species declined by 79 percent (spring) and 41 percent (autumn) between 1968 and 1982 due to the loss of wetlands. Continent wide wetland loss is a factor to migrating bird survival, but this has not been assessed for wetland species in the AOC. Guidelines for the protection of fish-eating wildlife have been exceeded in juvenile fish for PCBs and in juvenile fish, carp and channel catfish for octachlorostyrene. The effects of these exceedences, if any, on wildlife populations which consume these fish are not known.
Body burdens of Wildlife	B	Contaminants such as pentachlorobenzene, hexachlorobenzene, octachlorostyrene, PCBs and DDT have been found in snapping turtles, muskrats and ducks in the St. Clair Delta. The effects of these chemicals on wildlife are not known. Research on body burdens and associated effects in wildlife is required for the entire Great Lakes ecosystem.

Table 1.1 (cont'd)

GLWQA Impairment of Beneficial Use	Status of Impairment	Conditions in the St. Clair River
FISH TUMOURS AND OTHER DEFORMITIES	A	External tumours found in fish are due to natural viral factors. Although studies on the incidence of internal tumours have been limited in the AOC, there is one observation of an early neoplastic tissue change which was observed in a caged fish. Although this finding is not statistically significant, there is a growing consensus that there is sufficient evidence to suggest liver tumours are caused by chemical factors.
BIRD OR ANIMAL DEFORMITIES OR REPRODUCTIVE PROBLEMS	I	Mouth part deformities occur in some chironomid species but no evidence of bird or other animal deformities or reproductive problems has been reported.
DEGRADATION OF BENTHOS		
Dynamics of Benthic Populations	I	Benthic community health is good on the Michigan side of the river but, as of 1985, was impaired along the Ontario shore for a distance of about 12 km (7.4 mi) beginning in the reach between the Sarnia WPCP and Dow Chemical and extending downstream past Stag Island to approximately Novacor Chemical (Canada) at Mooretown.
Body Burdens of Benthic Organisms	B	Several types of benthic organisms, including native clams, mayflies (*Hexagenia spp*.), aquatic worms (Oligochaetes) have been found to bioaccumulate various organic and inorganic chemicals. The effects of these chemicals on benthic organisms is not known. Research on body burdens and associated effects in benthic organisms is required for the entire Great Lakes ecosystem.
RESTRICTIONS ON DREDGING ACTIVITIES	I	Concentrations of copper, cadmium, chromium, iron, lead, mercury, nickel, zinc, PCBs, total phosphorus and oil and grease along the Ontario shoreline exceed OMOE guidelines for the open water disposal of dredged sediments and all but PCBs, cadmium and nickel are classified as heavily polluted by the U.S. EPA interim guidelines for the disposal of Great Lakes harbor sediments. Most exceedences occur along the Sarnia industrial waterfront, as far downstream as the Lambton Generating Station, and the mouths of Talfourd Creek, Baby Creek and the Murphy Drain. Confined disposal has been required in some instances due to the presence of HCB. Concentrations of total Kjeldahl nitrogen, oil and grease, arsenic, copper, chromium, iron, lead and manganese from the Michigan shore are considered moderately or heavily polluted by U.S. EPA guidelines and exceed OMOE disposal guidelines. There are currently no restrictions on dredging or disposal of dredged material from U.S. waters of the St. Clair River due to the presence of contaminants.
EUTROPHICATION OR UNDESIRABLE ALGAE	NI	The waters of the St. Clair River are mesotrophic and algae do not occur at nuisance levels.

Table 1.1 (cont'd)

GLWQA Impairment of Beneficial Use	Status of Impairment	Conditions in the St. Clair River
RESTRICTIONS ON DRINKING WATER CONSUMPTION OR TASTE AND ODOUR PROBLEMS		
Consumption	I	Periodic closing of Water Filtration/Treatment Plants occur in both Michigan and Ontario as a result of chemical spills at upstream locations.
Taste and Odour Problems	I	The Health and Welfare Canada taste and odour aesthetic objective for ethylbenzene was exceeded at the Wallaceburg Water Treatment Plant during start-up following a spill in October 1990. Closures of the Wallaceburg WTP intakes based on level II responses are based on factors including taste and odour concerns.
BEACH CLOSINGS	I	There have been no beach closings in Michigan although all areas downstream of Michigan CSOs are identified as impaired areas due to the periodic discharge of inadequately treated sewage. In Ontario, five beaches were closed as recently as the summer of 1990 for up to two months duration due to coliform bacteria levels which exceeded both Ontario and Michigan standards.
DEGRADATION OF AESTHETICS	I	Floating scums, oil slicks, spills and odours have been periodically reported.
ADDED COST TO AGRICULTURE OR INDUSTRY	I	Food processing industries in Ontario and a salt processing facility in Michigan have had to temporarily shut down their intakes due to upstream spills. Costs have also been incurred for proper disposal of contaminated sediment removed from the river for construction or other purposes.
DEGRADATION OF PHYTOPLANKTON AND ZOOPLANKTON POPULATIONS	NI	Phytoplankton and zooplankton species in the river are typical of those in southern Lake Huron.
LOSS OF FISH AND WILDLIFE HABITAT	I	Habitat has been lost due to filling, draining, dredging and bulkheading for industrial (Sarnia), urban, agricultural and navigational uses. Significant losses of wetlands have occurred particularly in the delta region of the AOC. Fish and wildlife management goals are needed to help further determine the degree of impairment and guide rehabilitation strategies.

Table 1.1 (cont'd)

Exceedences of Water Quality Objectives, Guidelines or Standards Within the St. Clair River AOC	
Objectives/Standards	**Exceedences**
GLWQA Annex 1 Specific Objectives and Ontario PWQO for the Protection of Aquatic Life	Iron - Ontario, downstream of Sarnia and Chenal Ecarté Zinc - Walpole Island WTP intake Copper - Lambton and Walpole Island WTP intakes Cadmium - near Dow and Suncor outfalls Hexachlorobenzene (PWQO) - Ontario, Cole Drain to Stag Island; mouth of Talfourd Creek
Provincial Water Quality Guideline	Phosphorus - Wallaceburg Water Treatment Plant intake
Provincial Swimming and Bathing Use of Water	Bacteria - five beaches along Ontario shore closed due to exceedences during 1990
Michigan WQS, Rule 51 Michigan WQS, Rule 57(2), January 1991	Chloride - adjacent to Sarnia industrial waterfront Mercury - offshore and immediately downstream of Sarnia industrial area; Chenal Ecarté; and in raw water at Lambton, Walpole and Wallaceburg treatment plant intakes Zinc - Walpole Island WTP intake Copper - Lambton and Walpole Island WTP intakes Cadmium - near Dow and Suncor outfalls Lead - downstream of the mouth of the Black River Total PCBs - throughout river in Michigan and Ontario Dieldrin - throughout river in Michigan and Ontario Carbon Tetrachloride - offshore of Dow Chemical Hexachlorobenzene - Ontario, Cole Drain to Stag Island; mouths of Talfourd and Bowens Creeks; Chenal Ecarté Tetrachloroethylene - Ontario, offshore of Dow Chemical
Michigan WQS, Rule 62 (total body contact)	Bacteriav - five beaches along Ontario shore CSOs - all areas downstream of Michigan Combined Sewer Overflows.

[1] The Impairment Status 'requires assessment' in the St. Clair River AOC.

[2] The Impairment Status 'requires assessment' on a Great Lakes Basin basis.

[3] The date of data collection as well as the location and magnitude of the impairment is summarized in Table 6.23 (water quality), 6.30 (sediment) and 6.52 (biota).

In comparing the current loadings database (1986 to 1989 data) to the 1986 total loadings reported by UGLCCS (1988), loadings of suspended solids, cadmium, cobalt, zinc and octachlorostyrene appear to have increased. These higher loadings are in part due to the inclusion of more sources in the current report, particularly for suspended solids and total phosphorus. Increases in the metals reflect generally higher loadings from the Sarnia WPCP during 1987 than in 1986. Octachlorostyrene loadings are reflective of higher loadings reported for the Cole Drain.

Improvements, i.e., reduced loadings since 1986, include BOD5 (particularly significant as there are more sources for which data are reported), phenols and volatiles. Reduced phenol loadings have occurred at most Ontario industries in both the petroleum refining and organic chemicals sectors. Reduced volatile loadings at Dow have contributed to the greatest reductions since 1986. The total volatile loading values reported for Ethyl and Polysar are based on the 1986 survey and it is not known whether loadings have been reduced.

A significant portion of the volatile component for Polysar is benzene, whereas the major volatiles from Dow are 1,1-dichloroethane, 1,2-dichloroethane, 1,1,1-trichloroethane, carbon tetrachloride and tetrachloroethylene. Reductions in chlorinated organics from Dow, including hexachlorobenzene (>50%), octachlorostyrene (40%), tetrachloroethylene (62%) and hexachlorobutadiene (50%), have been reported for the period 1986/87 to 1990 based on a preliminary assessment of MISA self-monitoring data.

<u>Causes of Impairments</u>

In attempting to define remedial strategies for restoring beneficial uses, it is necessary to relate the impairments to chemicals and the sources of chemicals. Presently it is not possible to establish direct cause-effect relationships for every impaired use. However, it is possible to directly relate impairments resulting from biota and sediment criteria exceedences to a chemical and, hence, sources. Although not identified as a use impairment by the IJC, exceedences of water quality guidelines for the protection of aquatic life is a concern and can be related to specific chemicals and sources.

Table 1.2 lists those parameters which exceed guidelines (biota, sediment or water) and summarizes corresponding sources and loadings based on data presented in Chapter 8. Although spills are not included in this table, the number of spills and the large total loads contributed from some spills must be considered with regard to developing remedial options to restore impaired beneficial uses, particularly those related to restrictions on dredging activities, drinking water consumption, drinking water taste and odour problems and degradation of aesthetics.

Parameters designated as exceeding sediment criteria (Table 1.2) may cause restrictions on dredging activities in some locations. Costs associated with sediment analysis and confined disposal may also contribute to additional costs.

Concentrations of mercury and PCBs in certain species and sizes of sport fish have resulted in restrictions to fish consumption.

Benthic faunal communities were found in 1985 to be degraded or severely degraded in association with sediments which had the highest mean concentrations of copper, mercury, nickel, zinc, oil and grease, fibre, total organic carbon and total phosphorus. Sediments in portions of the river having degraded benthos were also found to have occasional exceedences of Ontario's biologically-based sediment guidelines for PAHs (lowest effect level) and hexachlorobenzene (lowest and severe effect levels).

Beach closings occur along the Ontario shore of the St. Clair River due to coliform bacteria densities which exceeded both Ontario and Michigan standards. In addition, all areas downstream of Michigan CSOs are identified as impaired areas due to the periodic discharge of inadequately treated sewage. Loadings of

Table 1.2 Contaminants which have been identified as exceeding guidelines in the St. Clair River AOC in comparison to sources and known source loadings (in kg/d unless noted otherwise).

Parameter	Media in Which Guidelines Exceeded[1]	Ontario				Michigan
		Point Sources[2]	Tributaries[3]	CSOs[4]	Stormwater[4]	Point Sources[2]
Cadmium	w,s	0.1909	-	0.013-0.02	0.01-0.11	-
Chromium	s	11.46[a]	-	-	-	-
Copper	w,s	10.38	-	0.37	0.89	0.64
Iron	w,s	488.5	235.7	7-22	112	42.3
Lead	w,s	14.19	0.911	0.8	5.0	0.23
Manganese	s	-	-	-	-	-
Mercury	b,w,s	0.0315	0.0064	0.0003-0.002	0.002-0.0022	-
Nickel	s	3.235	-	0.014-0.06	0.39-0.60	0.23
Zinc	w,s	65.52	3.305	0.63	6.03	2.57
Oil & Grease	s	2,053.65	-	20-92	110	622.23
Total Kjeldahl Nitrogen	s	-	-	-	-	-
Total Phosphorus	w,s	84.62	82.08	1.1-9.04	4.9	40.53
Arsenic	s	-	-	-	-	-
Bacteria (organisms/day)	w	-	1.04×10^{15}	4.25×10^{14}	-	-
Chloride	w	356,030	6,744	87-172	3,151-6,301	31,234
Octachlorostyrene	b,w	0.0135	0.00199	0.000005	0.00004	-

Table 1.2 (cont'd)

Parameter	Media in Which Guidelines Exceeded[1]	Ontario				Michigan
		Point Sources[2]	Tributaries[3]	CSOs[4]	Stormwater[4]	Point Sources[2]
Hexachlorobenzene	w,s	0.0208	0.0065	0.0	0.0022	-
Hexachlorobutadiene	w	0.183[a]	-	-	-	-
Tetrachloroethylene	w	3.11[a]	-	-	-	-
Carbon Tetrachloride	w	4.098[a]	-	-	-	-
Dieldrin	w	-	0.000118[b]	-	-	-
Total PAHs	s	0.518	-	0.014-0.041	0.13-0.162	ND
Total PCBs	b,w,s	0.0122	0.0709	0.0003-0.0006	0.0036	0.0027

- = data not available; ND = below detection.

1 b = biota, w = water, s = sediment.

2 From Table 8.49 (see footnotes in Table 8.49 to determine which are gross loadings and which are net loadings).

3 From Table 8.45 (data for Cole Drain in Table 8.49 subtracted from total tributary load shown in Table 8.45).

4 From Table 8.46.

5 From Table 8.47.

a From Table 8.31.

b From Text, Section 8.3.3.

bacteria from sources in the St. Clair River AOC have not been well documented, however, known sources of bacteria to the AOC include CSOs, stormwater, effluent from water pollution control plants, and other sources including agricultural runoff, private septic systems, and some industrial outfalls.

Floating scums, oil slicks, spills and odours have been periodically reported and contribute to the degradation of aesthetics. In addition to spills, ongoing discharges of oil and grease occurs from point sources as well as wet weather periodic discharges from Sarnia CSOs and stormwater (Table 1.2).

Ontario industrial and municipal point sources contribute the largest loadings of most contaminants to the St. Clair River AOC, in comparison with estimates from other sources located within the AOC. Upstream sources are estimated to contribute loadings of mercury, phosphorus, chloride and suspended solids comparable to total sources within the AOC. Other sources located within the study area which, based on the current database, contribute relatively large loadings of certain parameters include Ontario tributaries and Sarnia stormwater.

2.0 INTRODUCTION

2.0 INTRODUCTION

2.1 BACKGROUND

The Great Lakes are a unique natural resource containing 20 percent of the world's fresh surface water. These lakes also form a portion of the international boundary between Canada and the United States, and both countries have jurisdiction over their use. In order to protect this vast resource and cooperatively address problems along their common border, Canada and the U.S. interact through an agency known as the International Joint Commission (IJC).

The IJC was established by Canada and the U.S. under the authority of the Boundary Waters Treaty of 1909 which set forth the rights and obligations of both countries regarding all common boundary waters. The responsibilities of the IJC, as identified in the Boundary Waters Treaty include collecting, analyzing and disseminating data, and tendering recommendations to the Canadian and the U.S. governments regarding water quality problems in the boundary waters. As far back as 1912, the Canadian and the U.S. governments asked the IJC to investigate the extent and causes of pollution in the Great Lakes. The IJC identified specific locations, including the St. Clair River, that were polluted with raw sewage, identified pollution sources, and recommended specific actions to control the pollution. Water borne disease epidemics were eventually eliminated from the Great Lakes Basin as a result of such efforts.

Concern about other water quality problems, specifically (cultural) eutrophication, over the years resulted in the signing of the 1972 Great Lakes Water Quality Agreement (GLWQA) by Canadian and the U.S. governments. This agreement affirmed both countries' determination to restore and enhance Great Lakes water quality, and established general and specific water quality objectives for the Great Lakes system.

Since 1973, the IJC Water Quality Board has identified specific areas throughout the Great Lakes basin having serious water quality problems. These problem areas have been described and evaluated in annual and biennial Water Quality Board reports. In 1973, these areas were called "Problem Areas", and they varied in scope, complexity, and severity. Over the years, many of the problems in these areas have been resolved through the implementation of water quality standards, effluent regulations, industrial pretreatment programs, and construction and upgrading of wastewater treatment plants. As a result of these efforts, and the identification of new concerns, there have been many deletions and additions to the original list of Problem Areas.

The Water Quality Board soon realized that the Problem Areas approach lacked consistency in problem identification and assessment, and usually relied on water quality indications alone. In 1981, the Problem Areas were renamed "Areas of Concern" (AOCs). The name change reflected the IJC's desire to shift the problem perspective from limited water quality issues to a broader approach based on environmental quality data for water, sediment and biota and to evaluate the areas with uniform criteria. This new approach was consistent with the GLWQA of 1978 which served to shift the emphasis from conventional pollutants in the 1972 GLWQA to toxic pollutants, and incorporated an ecosystem approach in recognition of the need to consider all components of the system as they affect water quality. An AOC was defined by the Water Quality Board as an area where there is known impairment of a beneficial water use. In 1981, there were 39 AOCs that were divided into 2 classes based on the severity of the identified problems. The 1983 Water Quality Board's Report identified 18 AOCs, including the St. Clair River, that were "Class A". Class A AOCs represented the most degraded areas around the Great Lakes. The Report acknowledged that due to the severity of the problems in these areas, cleanup efforts would be long term endeavors.

In the 1985 Water Quality Board's Report on Great Lakes Water Quality a new approach for categorizing the AOCs was presented. This approach was based on the status of the data base, programs underway to fill data gaps, and remedial actions taken to address the identified problems. No effort was made to classify the

AOCs on the severity of the problems. In the 1985 report 42 AOCs were identified (Figure 2.1). A 43rd AOC, Presque Isle Bay, Pennsylvania, was designated by the U.S. Department of State in January 1991. The St. Clair River was identified as an AOC due to the following types of problems: conventional pollutants (e.g. bacteria), heavy metals, toxic organics, contaminated sediments, fish consumption advisories, impacted biota and beach closings. Sources of the problems were cited as municipal and industrial point sources, urban nonpoint sources, combined sewer overflows and contaminated sediments.

The jurisdictions and the IJC acknowledged that additional, specific guidance was needed to resolve the persistent pollution problems that remained in most of these AOCs. Therefore, the Province of Ontario and the eight Great Lakes states agreed to develop Remedial Action Plans (RAPs), or clean up plans, for the AOCs within their jurisdictional boundaries. The St. Clair River is within the boundaries of both Ontario and Michigan. Therefore, one RAP will be developed jointly by Ontario and Michigan for this AOC.

2.2 REMEDIAL ACTION PLANS AND THE AREAS OF CONCERN PROGRAM

In 1987, Canadian and the U.S. governments signed a Protocol Amending the Great Lakes Water Quality Agreement. The Protocol adds specific programs, activities and timetables that more fully address issues identified in the 1978 GLWQA. Annex 2 of the 1987 Protocol requires the development and implementation of Remedial Action Plans for the Great Lakes Areas of Concern. These RAPs are to serve as an important step toward virtual elimination of persistent toxic substances, and toward restoring and maintaining the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem. The GLWQA Annex 2(4) requires the parties to the agreement (U.S. and Canadian governments) to cooperate with State and Provincial governments to ensure that Remedial Action Plans are developed and implemented. The IJC is responsible for reviewing RAPs as they are developed and for tracking their implementation. The provincial and state governments, with cooperation from both federal governments, must also ensure that the public is consulted on development and implementation of the RAPs.

An AOC is defined in Annex 2 as "a geographic area that fails to meet the General or Specific Objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life". Fourteen use impairments are specified in the GLWQA, and the existence of any one could be sufficient to list an area as an AOC. The fourteen impaired uses are:

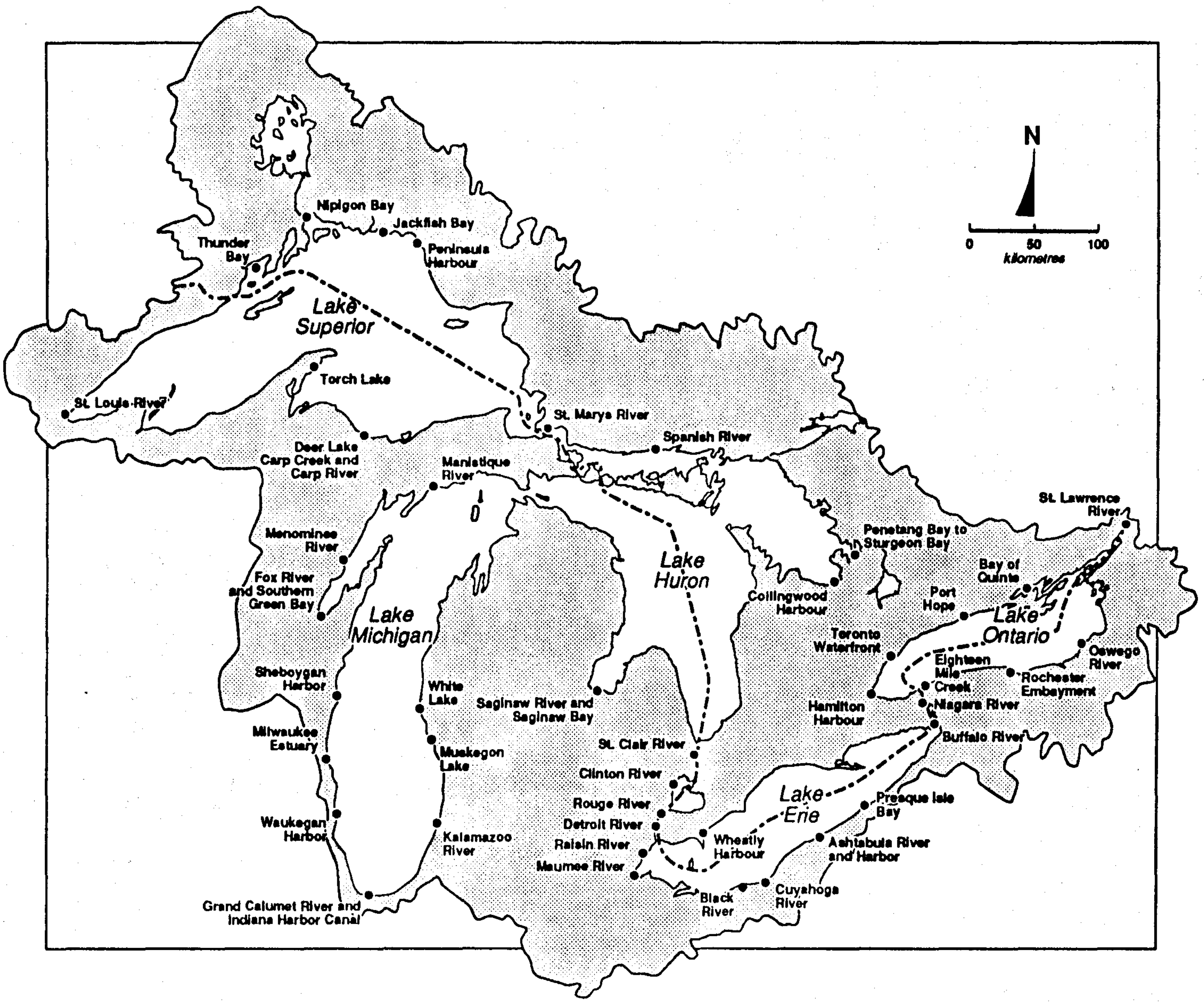
- (i) Restriction on fish and wildlife consumption;
- (ii) Tainting of fish and wildlife flavor;
- (iii) Degradation of fish and wildlife populations;
- (iv) Fish tumors or other deformities;
- (v) Bird or animal deformities or reproductive problems;
- (vi) Degradation of benthos;
- (vii) Restrictions on dredging activities;
- (viii) Eutrophication or undesirable algae;
- (ix) Restrictions on drinking water consumption, or taste and odor problems;
- (x) Beach closings;
- (xi) Degradation of aesthetics;
- (xii) Added costs to agriculture or industry;
- (xiii) Degradation of phytoplankton and zooplankton populations; and
- (xiv) Loss of fish and wildlife habitat.

In 1988, the Water Quality Board developed additional guidance for the parties to the GLWQA and the jurisdictions to identify AOCs and the impaired uses. This guidance (Appendix 2.1) establishes listing and delisting criteria for each of the 14 use impairments. As some of the criteria tend to be subjective, the jurisdictions, Parties and IJC must exercise good, sound judgment when listing AOCs, and when defining use impairments.

Figure 2.1

St. Clair River Remedial Action Plan

Areas of concern in the Great Lakes Basin



Annex 2 of the Protocol Amending the GLWQA identifies what must be included in each RAP, and specifies that the RAP should be submitted to the IJC for review and comment at three stages. The three stages and the contents of the RAP at each stage are as follows:

Stage 1. This portion of the RAP will define the problem(s) in the AOC and will include (i) a definition and detailed description of the environmental problem in the AOC, including a definition of the beneficial uses that are impaired, the degree of impairment and the geographical extent of the impairment; and (ii) a definition of the causes of the use impairment, including a description of all known sources of pollutants involved and an evaluation of other possible sources.

Stage 2. This portion of the RAP will define the specific goals for the AOC, and describe the remedial and regulatory measures selected to meet those goals. The Stage 2 RAP will include (i) an evaluation of remedial measures in place; (ii) an evaluation of alternative additional measures to restore beneficial uses; (iii) a selection of additional remedial measures to restore beneficial uses and a schedule for their implementation; and (iv) an identification of the persons, agencies, or organizations responsible for implementation of the selected remedial measures.

Stage 3. This portion of the RAP will be submitted when identified beneficial uses are restored. The Stage 3 RAP will include (i) a process for evaluating the implementation and effectiveness of remedial measures; and (ii) a description of surveillance and monitoring processes to track the effectiveness of remedial measures and the eventual confirmation of the restoration of uses.

2.3 St. CLAIR RIVER RAP

This document is intended to meet the requirements of a Stage 1 RAP for the St. Clair River. The problems, their causes, and the sources of pollutants of concern, as known to date, have been defined by the public, Ontario Ministry of the Environment (OMOE), Michigan Department of Natural Resources (MDNR), and other participating agencies. This RAP contains the technical documentation that will be used by the agencies and public when determining the water use and quality goals for development of the Stage 2 RAP for the St. Clair River. In turn, the goals will establish the general direction for future remedial actions.

In developing this Stage 1 RAP, available environmental quality data were compared with the "listing criteria" to determine which uses are impaired in the St. Clair River. Other problems may have also been identified due to exceedences of water quality standards or effluent requirements. Once the use impairments and (any) other problems were identified, the causes of those problems, and the sources and loadings of specific contaminants of concern were determined. The public (both individuals and organizations) and various levels and types of government agencies were included throughout the Stage 1 RAP development process (see Chapter 3, Participants) in an attempt to reach consensus on the problems in the St. Clair River. Involvement of those people and agencies not directly responsible for developing this RAP will continue through the Stage 3 RAP. This is viewed as an important and necessary part of the RAP process if future improvements in the aquatic ecosystem are to reflect the scientific and economic realities, and public desires.

The entire RAP (all stages) is a technical planning document for addressing aquatic ecosystem problems in the St. Clair River. This RAP is not the first of such efforts -- water pollution reduction programs have been ongoing for over 40 years -- nor is it the only effort. Regulatory agencies intend to continue their efforts to control pollutant sources and improve environmental quality as the RAP is developed. Remedial actions and regulatory measures that are identified and immediately implementable will proceed regardless of the status of RAP development.

The RAP process is viewed as a long-term, iterative process. Periodic updates and revisions may be required as more data become available, remedial measures are implemented, and environmental conditions improve.

The RAP process itself will eventually end when data confirm that established goals have been met, and that identified beneficial uses have been restored. Although the RAP process may end, efforts to restore and enhance environmental quality will continue.

3.0 PARTICIPANTS

3.0 PARTICIPANTS

3.1 RAP TEAM

The Remedial Action Plan (RAP) for the St. Clair River Area of Concern (AOC) was initiated in 1985. The St. Clair River forms an international boundary and, hence, Ontario and Michigan are jointly responsible for the RAP preparation. In 1985, an agreement was signed by Premier David Peterson of Ontario and Governor James Blanchard of Michigan providing that a joint RAP would be prepared, and giving Ontario the lead role for this endeavor.

A binational group called the RAP Team was established in 1987 to develop the plan and ensure adequate and appropriate public involvement. The RAP Team includes representatives from the Federal, Provincial, and State governments. The RAP Team is co-chaired by representatives from Ontario Ministry of the Environment (OMOE) and the Michigan Department of Natural Resources (MDNR). A list of RAP Team members and former members is included in Appendix 3.1. In October, 1988, the Binational Public Advisory Council (BPAC) (described in Section 3.2.3) selected four of its members as representatives on the RAP Team to facilitate communication between the RAP Team and BPAC.

Government members of the RAP Team are responsible for the actual writing of the RAP. A technical writer, Mr. D. Cowell of Geomatics International (not a member of the RAP Team) retained by the OMOE compiled relevant information and drafted the majority of the RAP. A member of the RAP Team provided input and guidance to the technical writer on the content and development of each draft chapter. Each draft chapter was then reviewed by the entire RAP Team. RAP Team meetings are held as needed.

The members of the St. Clair River RAP Team, as of July, 1991 were:

Dean Barnett - BPAC Member, U.S.
John Brisbane - OMNR, Chatham
Lois Burgess - OMOE, Sarnia
Ron Denning - BPAC Member, Canada
Tim Eder - BPAC Member, U.S.
John Jackson - BPAC Member, Canada
Ora Johannsson - DFO, Burlington
Gary Johnson - OMOE, Sarnia
Peter Kauss - OMOE, Toronto
Diana Klemans - Co-Chair - MDNR, Lansing
Maureen Looby - Co-Chair - OMOE, Sarnia
Bill Melville - U.S. EPA, Chicago
Doug Morse - MDNR, Lansing
Darrell Piekarz - DOE, Toronto
Kathy Schmidtt - MDNR, Detroit District Office
Ron Spitler - MDNR, Livonia
Stewart Thornley - OMOE, London

3.2 PUBLIC PARTICIPATION

Development of the RAP has two major components: technical information compilation and public participation. Public participation is an important and necessary component as it serves to inform the public, improve the plan by gaining information and advice from the public, gain support for plan implementation, and provide a mechanism for accountability to the public.

The need for a comprehensive public participation program for the St. Clair River was recognized early in the process. As the agreed upon lead agency for the St. Clair River RAP, the OMOE hired a consultant to assist in the development of a public participation program plan. The MDNR has, periodically, contracted with the Southeast Michigan Council of Governments (SEMCOG) to conduct specific public participation activities and disseminate information to the public.

To assist in the dissemination of information, the RAP Team established 8 reference centers (Appendix 3.2), and developed a St. Clair River Remedial Action Plan Newsletter (see Appendix 3.3 for an example). The newsletter is available to all interested citizens. It is used to highlight various issues of concern regarding St. Clair River water quality and to keep citizens apprised of the activities of the BPAC and RAP Team.

3.2.1 Displays

Display panels were designed to communicate the goals and objectives of the St. Clair River RAP to the general public. The display has been used at various community events, in an attempt to broaden public awareness about the clean-up plan.

3.2.2 Public Meetings

An initial public meeting, organized by the St. Clair River RAP Team, was held February 4, 1988. The meeting focused on the St. Clair River as an Area of Concern and consisted primarily of presentations by the RAP Team on the Remedial Action Plan development process, public involvement and the water quality issues pertinent to the St. Clair River RAP. This first meeting was attended by 139 persons from Michigan and Ontario.

One additional public meeting was held April 6, 1989. This was a joint Public/BPAC meeting for the purpose of presenting the conclusions and findings of the Upper Great Lakes Connecting Channels Study. The locations of the public meetings and presentation/discussion topics are reported in Appendix 3.4.

3.2.3 Binational Public Advisory Council (BPAC)

The public participation plan which was agreed to by the St. Clair River RAP Team included the development of a Binational Public Advisory Council (BPAC) to provide a channel for informed and continuous public participation. The St. Clair River BPAC was created during Spring 1988 for the purpose of advising the RAP Team on all aspects of the planning process including: goals, problem identification, planning methodology, public involvement program, technical data, remedial action alternatives, plan recommendations, and plan adoption.

The Council consists of members and alternates from Ontario members and Michigan, representing the following interest groups:

- Conservation and Environment
- Health
- Tourism/Recreation
- Business and Industry
- Native Peoples
- Labor
- Commerical Fisheries
- Agriculture
- Community Groups
- Municipalities
- Provincial/State Agencies
- Citizens at large

Many of the persons nominated for the BPAC were identified as a result of their interest and informed participation at previous public meetings. A complete list of BPAC representatives and their affiliations is included in Appendix 3.5. Technical experts as well as a number of groups with a wide range of concerns and interests are represented on BPAC.

St. Clair River RAP Binational Public Advisory Committee members (M) and alternates (A) as of July 1991:

CANADA	UNITED STATES
Mr. Bob Allen (A)	Mr. Dean Barnett (M)
Ms. Dana Atwell (M)	Ms. Laura Barnowski (A)
Mr. Malcolm Boyd (M)	Mr. Nicholas Barsheff (M)
Mr. Paul Carter (M)	Ms. Janet Collard (A)
Mr. Donald Craig (M)	Mr. Richard Curley (M)
Mr. Ron Denning (M)	Lt. Commander Dan Conrad (M)
Mr. Robert F. Harrison (A)	Senator Dan DeGrow (M)
Mr. Stewart Forbes (A)	Mr. Tim Eder (M)
Mr. Kenneth G. Smy (M)	Mr. Dan Gunning (M)
Mr. William Gelevan (M)	Mr. John Heidtke (M)
Mr. Jim Greenshields (A)	Mr. Donald Isaac (A)
Dr. Chris Greensmith (M)	Mr. Frederick J. Kemp (M)
Mr. Murray H. McKinnon (A)	Dr. Marshall Kamer (M)
Mr. Ian Harris (M)	Ms. Sharon L. Bender (M)
Mr. John Jackson (M)	Mr. Charles Lightfoot (A)
Mr. Harry Joosse (M)	Representative Terry London (M)
Mr. Robert Lalonde (M)	Mr. Timothy Lozen (M) - U.S. Co-Chair
Ms. Kristina Lee (M)	Ms. Mary Mechtenberg (A)
Mr. Stewart Lyall (A)	Mr. Timothy Morse (M)
Mr. Ken MacKenzie (M)	Ms. Diane Netter (A)
Mr. Colin McLuckie (M)	Mr. Lawrence O'Keefe (M)
Dr. George N. Werezak (M)	Mr. Jon Parsons (A)
Mr. Terry Plain (M)	Mr. Wilf Pennington (M)
Mr. Don Poore (M) - Canadian Co-Chair	Mr. Milford Purdy (A)
Mr. Tim Purdy (M)	Mr. R.J. (Hap) Rourke (M)
Mr. Darrell Randell (A)	Dr. Clair Scheurer (A)
Mr. Geof Smith (A)	Mr. Robert Spagnoli (M)
Mr. Doug Steen (A)	Ms. Gale Stein (A)
Ms. Dona Stewardson (M)	Mr. Joe Stockhausen (M)
Mr. Ron Tack (M)	Mr. John Tironi (M)
Mr. John Tiedje (M)	Mr. Al Whitsitt (M)
Mr. Clayton Wardell (A)	
Mr. C.J. (Bud) West (M)	
Chief Robert Williams (M)	

The BPAC's adopted charge is as follows:

The Advisory Council shall advise the RAP Team on key aspects of the Remedial Action Plan preparation and adoption. This includes: the goals of the plan, problems to be addressed, planning methodology, public involvement program, technical data, remedial action alternatives, planning recommendations and adoption, plan implementation, plan funding, and methods of enforcement. The goal of all concerned should be to arrive at planned recommendations upon which both the RAP Team and the Advisory Council agree, and for which there is broad public support.

The charge, scope and focus for St. Clair River BPAC activities are put forth in the BPAC's Mission Statement (Appendix 3.6). The Mission Statement was adopted by BPAC in May 1989.

The process of developing the St. Clair River RAP includes input, review and comment by the BPAC on the draft RAP as written by the RAP Team. To assist in this process, the RAP Team provided information and arranged for background presentations to the BPAC as work progressed on the RAP. BPAC meetings were held as necessary, generally monthly. A complete listing of BPAC meeting dates and discussion topics is included in Appendix 3.7. In addition, as previously mentioned, the BPAC selected four of its members as members of the RAP Team. BPAC representation on the RAP Team added input from the BPAC to the writing process. The entire BPAC reviewed and commented on the individual chapters as they were completed by the RAP Team.

3.3 TECHNICAL EXPERTISE

Although a formal technical advisory committee was not organized to assist in development of the RAP, numerous experts were contacted to contribute relevant data, assist with specific questions, to review the draft RAP for technical content and completeness, and to give presentations to the BPAC and RAP Team. Individuals having expertise in various subjects relevant to the RAP were called on from OMOE, Ontario Ministry of Natural Resources (OMNR), Environment Canada, Fisheries and Oceans Canada, U.S. EPA, U.S. Geological Survey, U.S. Fish and Wildlife Service, United States Army Corps of Engineers, Michigan Department of Public Health, local health departments, and Michigan Department of Natural Resources, local parks, International Joint Commission, various universities, and others who had data to share.

3.4 GOVERNMENT AGENCIES

Government agencies participating in the development of the RAP included Environment Canada, Fisheries and Oceans Canada, the U.S. Environmental Protection Agency, Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, Michigan Department of Natural Resources.

3.5 RESPONSIBILITY FOR IMPLEMENTATION

Overall responsibility for coordinating implementation of the RAPs lies with the two lead agencies; the Ontario Ministry of the Environment (on behalf of COA) and Michigan Department of Natural Resources. Specific actions may be conducted by Federal, Provincial/State and local governments, industries and researchers depending on the particular action and jurisdiction.

4.0 REGULATORY PROGRAMS

4.0 REGULATORY PROGRAMS

Numerous programs, regulations, objectives, guidelines and agreements to maintain and enhance environmental quality are in place and/or under development in Ontario, Michigan, and at the federal levels in both Canada and the United States. Many of the programs and regulations relevant to the control and enhancement of environmental quality in the St. Clair River AOC are outlined in this chapter. Legislation applicable to this discussion is listed in Appendix 4.1. The discussion is intended to outline the major aspects of the most important regulatory programs that affect environmental quality in the AOC. The chapter is organized by jurisdiction to point out the regulatory tools that each has to work with at this point in time. It is not the intent to compare or contrast programs, but rather to present information that will form the basis of many decisions affecting the AOC.

The determination of whether a beneficial use is impaired will be based on the IJC listing/delisting criteria (discussed in Chapter 2) and also to a large degree on compliance with existing policies, regulations, standards, etc. Of particular importance in this regard are the ambient water quality criteria that are established for the protection of water quality and/or water uses (by humans and other life). Although these criteria and their applications are discussed in detail under the appropriate jurisdictional section, Table 4.1 is provided as a quick reference. This table summarizes the Michigan Water Quality Standards, Ontario Provincial Water Quality Objectives and the Great Lakes Water Quality Agreement Specific Objectives for toxic substances. All will be used to assist in the determination of whether a use is impaired and whether exceedences of water quality standards occur. U.S. EPA criteria are not included because they are not directly applicable to the AOC.

The Stage 2 RAP will contain recommendations that are consistent with the legislation, policies, standards and programs described in this Chapter. Stage 2 may also recommend new programs or changes to existing regulatory programs if existing programs have been shown to be ineffective in protecting beneficial uses.

4.1 ONTARIO

4.1.1 Environmental Legislation

Environmental quality of the Great Lakes in Ontario is regulated by the province through federal and provincial environmental statutes (Table 4.2). Regulations promulgated under these statutes, (e.g. *Ontario Water Resources Act*, the *Ontario Environmental Protection Act* and the *Pesticides Act*) are intended to ensure that the quality of the water, biota, air, and lands are maintained within the province.

Many of these acts and regulations provide the legislative authority to control and restrict the discharge of contaminants into the air or water or onto the land. They specify numerous prohibitions that define what constitutes a contaminant and permitible discharge. The acts specify abatement mechanisms and procedures, such as Control Orders and Minister's Orders which are used to specify legally enforceable control strategies. The acts and regulations also specify permitting processes (Certificates of Approval) to ensure adequate collection, handling, treatment and disposal of wastes, including wastewaters, atmospheric discharges and solid wastes.

4.1.2 Water Quality Objectives

Ontario established goals and policies for the management of the quality and quantity of surface and groundwaters in 1978 under the *Ontario Water Resources Act*. Surface water quality must be satisfactory for aquatic life, recreation and potable water supply. The Provincial Water Quality Objectives (PWQOs) are a set of numerical and narrative criteria to protect aquatic life and recreation in and on surface water (OMOE 1984).

Table 4.1 Applicable Surface Water Quality Criteria for Toxic Substances.

Chemical Name	Ontario Provincial Water Quality Objective (μg/L)	Michigan Rule 57(2) Allowable Level (μg/L)[a]	GLWQA Specific Objective (μg/L)
Arsenic	100	184.0	50.0
Cadmium	0.2(e)	0.41(b)	0.2
Chromium	100	48.10(b)	50.0
Copper	5(f)	10.72(b)	5.0
Cyanide	5	4.0	---
Lead	1, 3, 5(g)	2.88(b)	25.0
Nickel	25	33.34(b)	25.0
Selenium	100	20.0	10.0
Silver	0.1	0.1	---
Zinc	30	49.57(b)	30.0
Molybdenum	---	800.0	---
Paraquat	---	16.0	---
PCB	0.001	0.00002	---
Polybrominated Biphenyls	0(i)	---	---
Formaldehyde	---	171.0	---
DDT + metabolites	0-0.003(i)	0.00023	0.003
Phenol, 2,4-dinitro	---	9.8	---
Carbon tetrachloride	---	20.0	---
Chlordane	0.06	0.00053	0.06
Lindane	0.01	0.097	0.01
Phenol, 4-chloro-3methyl	---	4.4	---
Dieldrin	---	0.0000315	---
Aldrin/Dieldrin	0.001(i)	---	0.001
Aniline	---	4.0	---
Acetone	---	500.0	---
Chloroform	---	43.0	---
Hexachloroethane	---	13.0	---
Benzene	---	60.0	---
Ethane, 1,1,1-trichloro	---	117.0	---
Bromomethane	---	11.0	---
Vinyl chloride	---	3.1	---
Methylene chloride	---	59.0	---
Ethylene oxide	---	56.0	---
Bromoform	---	65.0	---

Table 4.1 (Cont'd)

Chemical Name	Ontario Provincial Water Quality Objective (μg/L)	Michigan Rule 57(2) Allowable Level (μg/L)[a]	GLWQA Specific Objective (μg/L)
Bromodichloromethane	---	24.0	---
Ethylene, 1,1-dichloro	---	2.6	---
Heptachlor	---	0.002	---
Heptachlor/Heptachlor Epoxide	0.001	---	0.001
Hexachlorocyclopentadiene	---	0.5	---
Isophorone	---	860.0	---
Propane, 1,2-dichloro	---	64.0	---
Ethane, 1,1,2-trichloro	---	65.0	---
Trichloroethylene	---	94.0	---
Acrylamide	---	900.0	---
Ethane, 1,1,2,2-tetrachloro	---	30.0	---
Pentachlorophenol < = pH 8.1	0.5	20.23(c)	---
Pentachlorophenol > = pH 8.1	0.5	23.0	---
2,4,6-Trichlorophenol	---	1.5	---
Dinoseb	---	0.80(c)	---
Naphthalene	---	29.0	---
Benzidine, 3,3-dichloro	---	0.06	---
Benzidine	---	0.0399	---
Silvex	---	21.3	---
Acetic Acid, 2,4-dichlorophenoxy	4.0	46.7	---
Benzene, 1,2-dichloro	2.5	7.0	---
Phenol, 2-chloro	---	10.0	---
Ethylbenzene	---	30.0	---
Styrene	---	19.0	---
Benzene, 1,4-dichloro	4.0	15.0	---
Phenol, 4-chloro	7.0	9.3	---
Ethylene dibromide	---	1.10	---
Acrolein	---	3.0	---
PAH	60 pg/L(h)	---	
Ethane, 1,2-dichloro	---	560.0	---
Acrylonitrile	---	2.20	---
Toluene	---	100.0	---
Chlorobenzene	---	71.0	---
Phenol	1	110.0	---

Table 4.1 (Cont'd)

Chemical Name	Ontario Provincial Water Quality Objective ($\mu g/L$)	Michigan Rule 57(2) Allowable Level ($\mu g/L$)[a]	GLWQA Specific Objective ($\mu g/L$)
Bis(2-chloroethyl)ether	---	4.20	---
Bis(2-chloroethoxy) methane	---	4.60	---
Hexachlorobenzene	0.0065	0.0018	---
Benzene, 1,2,4-trichloro	0.5	22.0	---
Phenol, 2,4-dichloro	0.2	37.74(c)	---
1,4-dioxane	---	2000.0	---
Chlorodibromomethane	---	29.0	---
1,2,3,5-Tetrachlorobenzene	0.1	---	---
1,2,3-Trichlorobenzene	0.9	---	---
1,2,4,5-Tetrachlorobenzene	0.15	---	---
Pentachlorobenzene	0.03	---	---
Tetrachlorophenols	1.0	---	---
Trichlorophenols	16	---	---
Dibutylphthalate	4	---	---
Diethylhexylphthalate	0.6	---	---
Other phthalates	0.2	---	---
Tetrachloroethylene	---	16.0	---
Ethylene, t-1,2-dichloro	---	300.0	---
Benzene, 1,3-dichloro	2.5	179.0	---
1,2,3,4-Tetrachlorobenzene	0.1	0.76	---
Xylene	---	59.0	---
Tetra n-butyl ammonium bromide	---	140.0	---
2,3,7,8-TCDD	---	0.000000014	---
Di-n-propyl formamide	---	63.0	---
Mercury, methyl	---	0.0013	---
Mercury, total filtered	---	---	0.2
Mercury, filtered	0.2	---	---
Vanadium	---	3.73	---
Ammonia, unionized (coldwater)	20.0(d)	20.0	20.0
Ammonia, unionized (warmwater)	20.0(d)	50.0	---
Ammonia, total	0.2	---	500.0
Fluorides (soluble fluorides)	---	2000.0	---
Fluoride, total	---	---	1200.0
Chlorine	2.0	6.0	---

Table 4.1 (Cont'd)

Chemical Name	Ontario Provincial Water Quality Objective ($\mu g/L$)	Michigan Rule 57(2) Allowable Level ($\mu g/L$)[a]	GLWQA Specific Objective ($\mu g/L$)
Hydrogen sulfide	2.0	0.55	---
DBNPA	---	4.0	---
Chromium, hexavalent	---	2.0	---
Bis(chlorobutyl)ether	---	60.0	---
Total Resin Acids	1-61.5(j)	---	---
Methoxychlor	0.04	---	0.04
Mirex (mg/L)	0-0.001(i)	---	substant. absent
Toxaphene	0.008	---	0.008
Phthalatic esters	---	---	0.2 - 4.0
Endrin	0.002	---	0.002
Chlorpyritos	0.001	---	---
Diazinon	0.08	---	---
Dicamba	200	---	---
Diquat	0.5	---	---
Diuron	1.6	---	---
Dalapon	110	---	---
Endosulphan	0.003	---	---
Fenthion	0.006	---	---
Guthion	0.005	---	---
Malathion	0.1	---	---
Parathion	0.008	---	---
Pyrethrum	0.01	---	---
Simazine	10	---	---

Comment Codes

a) See Table 4-12 for basis. January 15, 1991 Update.
b) Based on a water hardness of 100 mg/L.
c) Based on a pH of 8.0.
d) pH and temperature dependent, not to exceed 20 $\mu g/L$ unionized.
e) In waters with hardness between 0-100 mg/L as $CaC0_3$. For waters with hardness 100 mg/L PWQO is 0.5 $\mu g/L$.
f) PWQO is 1 $\mu g/L$ for hardness between 0-20 $\mu g/L$ as $CaC0_3$; 5 $\mu g/L$ for hardness 20 $\mu g/L$ as $CaC0_3$.
g) Inorganic lead for hardness of 0-30, 30-80 and 80 mg/L, respectively.
h) Provincial Water Quality Guidelines (PWQG) for Benzo(a)pyrene.
i) As per narrative outlined in OMOE 1984 "Blue Book".
j) pH dependent (note: PWQG Guideline).

Table 4.2 Environmental Legislation Affecting the Great Lakes and Connecting Channels.

Ontario Acts	Media or Activity Addressed												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Ontario Water Resources Act (OWRA)	1	3	1	1	1					2		1	
Ontario Environmental Protection Act (EPA)	3	2	3	1	1	1		2	1	3	1		2
Environmental Assessment Act	3	3	3	3	3	3		3	3				
Dangerous Goods Transportation Act						1					1		
Drainage Act										2			
Pesticides Act							1			1			
Public Lands Act			1										

Key to Codes:

A: Ambient Surface Water and Ground Water Quality and Management
B: Sediment Quality and Management
C: Biota Quality and Habitat Management
D: Industrial Point Source Discharge Control
E: Municipal Point Source Discharge Control
F: Solid and Hazardous Waste Management
G: Pesticide Manufacture and Management
H: Urban Runoff and Combined Sewer Overflow Management
I: Air Point Source Discharge and Ambient Air Quality Control
J: Agricultural Land Management
K: Spills and Shipping Activities
L: Drinking Water Quality Control and Management
M: Fish Consumption Guidelines or Advisories
1: Legislation is responsible for legally enforceable standards and/or has direct authority over the media or activity.
2: Legislation provides non-enforceable guidance or authority over media or activity.
3: Legislation is not directly applicable to the media or activity, but media/activity may be impacted by execution of its legislative mandate.

Numerical PWQOs are given in Table 4.3. In the absence of reference to further descriptive information contained in the Ontario "Blue Book", the objectives represent maximum values (OMOE 1984). PWQOs represent a desirable level of water quality that the OMOE strives to maintain in surface waters of the province. They are often the starting point in deriving effluent requirements.

The PWQOs are under constant review and may be revised as more information becomes available. In 1984 the Ministry of the Environment had more than 70 substances with undefined tolerance limits for which there was insufficient scientific data to establish PWQOs (OMOE 1984). The list continues to grow. In 1989 the Ministry issued the Handbook for the Parameter Listing System which summarized the various drinking water quality limits established by some 16 agencies worldwide for more than 600 compounds. The presence and/or discharge of these compounds is evaluated on a case-by-case basis.

The protection and control of water quantity focuses primarily on flood and erosion control. These are the responsibility of the Ontario Ministry of Natural Resources and local Conservation Authorities. OMOE has the responsibility of issuing 'water taking permits' under the *Ontario Water Resources Act*.

Table 4.3 Ontario Provincial Water Quality Objectives (PWQO) for the protection of aquatic life and recreational uses.

PARAMETER	PWQO[1]
Alkalinity	25% decrease[1]
Ammonia, mg/L	0.02[1]
Barium, mg/L	
Boron, mg/L	
Chloride, mg/L	
Chlorine, mg/L	0.002
Color, TCU	
Copper, mg/L	
Cyanide (free), mg/L	0.005
Dissolved Gases	110% Sat.
Dissolved Oxygen, mg/L	4-8
Fluoride, mg/L	
Hydrogen Sulfide, mg/L	0.002
Manganese, mg/L	
Methane, $1/m^3$	
Nitrate (as N), mg/L	
Nitrite (as N), mg/L	
Heavy Metals, $\mu g/L$	
Arsenic	100
Beryllium	11-1100[1]
Cadmium	0.2
Chromium	100
Copper	5
Iron	300
Lead	5-25[1]
Mercury	0 to 0.2[1]
Nickel	25
Selenium	100
Silver	0.1
Zinc	30
Uranium, mg/L	.

Table 4.3 (cont'd)

PARAMETER	PWQO[1]
Bacteria (per 100ml)[1]	
Standard Plate Count	
Total Coliform	1000
Fecal Coliform	100
Fecal Streptocci	
Pseudomonas aeruginosa	
Staphylococcus aureus	
Trihalomethanes, mg/L	
Industrial Organics, mg/L	
Dibutylphthalate	4
Diethylhexyphthalate	0.6
Other Phthalates	0.2
Mirex	0-0.001[1]
Polychorinated Biphenyls	0-0.001[1]
Polybrominated Biphenyls	0[1]
Oil & Grease[2]	
Organic Nitrogen, mg/L ($TKN-NH_3$)	
pH	6.5-8.5
Phenols, μg/L	1
Phosphorus(total),mg/L	10-30[1]
Radionuclides, Bq/L[1]	
Cesium 137	50
Iodine 131	10
Radium 226	1
Strontium 90	10
Tritium	40,000
Sulphate, mg/L	
Temperature, °C	10°C increase or max 30°C[1]
Total Dissolved Solids, mg/L	
Total Organic Carbon, mg/L Turbidity	10% secchi depth increase

Table 4.3 (cont'd)

PARAMETER	PWQO[1]
Pesticides, μg/L	
Aldrin/Dieldrin	0.001[1]
Carbaryl	
Chlordane	0.06
Chlorpyrifos (Dusban)	0.001
Diazinon	0.08
Dicamba (Banvel)	200
Diquat	0.5
Diuron	1.6
Dalapon	110
Endosulphan	0.003
Endrin	0.002
Fenthion (Baytex)	0.006
Guthion	0.005
Heptachlor & Heptachlor Epoxide	0.001
Lindane	0.01
Malathion	0.1
Methoxychlor	0.04
Methyl Parathion	0.008
Pyrethrum	0.01
Simazine	10
Toxaphene	0.008
DDT & Metabolites	0-0.003[1]
2,4-D (BEE)	4
2,4,5-TP	
Dibenzofurans/dioxins (pg/L)	

(1) From OMOE (1984) Water Management, Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment, Toronto.
(2) Oil and Grease guideline is a narrative which states: "Oil or petrochemicals should not be present in concentrations that:
-can be detected as a visible film, sheen, or discolouration on the surface;
-can be detected by odour;
-can cause tainting of edible aquatic organisms;
-can form deposits on shorelines and bottom sediments that are detectable by sight or odour, or are deleterious to resident aquatic organisms." (OMOE 1984).

4.1.3 Point Source Controls

Municipal and industrial direct discharges to receiving waters are controlled by Ontario's Municipal and Industrial Effluent Objectives (Table 4.4) established under the OWRA and the EPA. In addition, site-specific effluent requirements protect the quality of the receiving water. Site specific requirements are based on Policy 3 of the Ministry's Water Management Goals, Policies, Objectives and Implementation Procedures (OMOE 1984).

Table 4.4 Ontario Municipal and Industrial Effluent Objectives (mg/L unless noted).

Parameter	Ontario Industrial Effluent Objectives	Ontario Municipal Effluent Objectives
BOD5	15	20
Suspended Solids	15	25
Oil and Grease	15	15
Ammonia-Nitrogen	10	-
Fecal Coliforms, MF/100ml	-	400
pH, SU Units	5.5 - 9.5	6-9
Total Phenols	0.02	0.02
Total Phosphorus	-	1
Total Residual Chlorine	-	0.5
Cadmium	0.001	-
Chromium*	1.0	-
Copper*	1.0	-
Lead	1.0	-
Mercury*	0.001	-
Nickel*	1.0	-
Tin*	1.0	-
Zinc*	1.0	-

* Total metals concentration not to exceed 1.0 mg/L

Policy 3 dictates that effluent limits will be established based on the waste receiving capacity of a waterbody and the Provincial Water Quality Objectives. Consideration will also be given to the Federal or Provincial effluent regulations or guidelines, and control of nonpoint sources of pollution. Effluent requirements will be determined following appropriate site specific receiving water assessments. This effluent requirement will be compared to Federal effluent regulations or Provincial effluent regulations or guidelines for existing or proposed new or expanded effluent discharges. The more stringent of the effluent requirement, regulations or guidelines will be imposed. The effluent requirement derived from this procedure for proposed new or expanded discharges will be incorporated into a Certificate of Approval in both waste loadings and concentrations.

Certificates of Approval (CofA) for treatment works are issued under the OWRA. In the past, the CofA was an approval to install pollution control equipment with the design specifications shown in the CofA. Recently, some approvals include legally enforceable effluent limits which appear in the CofA.

Certificates of Approval are also issued to municipal Water Pollution Control Plants (WPCPs). These CofA's usually only describe control equipment modifications or specifications; however, some do contain effluent limits.

The provincial EPA Sewage System Regulations set standards for the construction and operation of sewage systems and the licensing of related businesses. Municipal storm sewer-use by-law control parameters and limits specify the concentration of various parameters, mainly conventional pollutants and metals. Municipal sanitary sewer-use by-law control parameters are similar in scope and degree of control, and apply to all industrial dischargers to the municipal facility. Additional pretreatment requirements, such as technology-based pretreatment, are not specified. However, these by-laws contain a clause enabling the municipality to require oil interceptors, flow monitors, manholes and treatment, as necessary, to meet the by-law limits (without dilution).

Legally enforceable Control Orders may be issued under Section 113 of the EPA to any existing plant. Control Orders define tasks and compliance dates by which specific tasks must be completed.

The Guidelines for Control of Industrial Phosphorus Discharges in Liquid Effluents, issued under EPA, are intended to provide guidelines for phosphorus discharges and water quality management consistent with municipal sewage systems. The objective of 1 mg/L phosphorus concentration in industrial effluents is based on the use of practicable control technology to control or eliminate phosphorus. Facilities discharging one million gallons per day or more of effluent are subject to the phosphorus limitation of 1 mg/L.

The provincial government, in consultation with Environment Canada, published a White Paper entitled "Municipal-Industrial Strategy for Abatement (MISA)" in June, 1986. The White Paper provides the framework for the control of toxic contaminants in industrial and municipal effluents; initially, through a regulatory component to enforce technology-based effluent limits. The minimum pollution control requirement will be based on the implementation of "Best Available Technology Economically Achievable (BATEA)". As treatment technologies are advanced, BATEA requirements will be adjusted, moving towards the goal of virtual elimination of persistent toxic contaminants. This is consistent with the policies stated in the Great Lakes Water Quality Agreement as amended in 1987. Development of these controls will be accomplished through the promulgation of Effluent Monitoring Regulations and Effluent Limits Regulations directed at municipal and industrial sectors in order to achieve water pollution control at its source.

Opportunity for public involvement has been afforded and is summarized in Public Review of the MISA White Paper and the OMOE's Response (MISA OMOE 1987). Under the MISA program, a monitoring regulation sets legal requirements for sampling, analysis (including quality assurance and quality control), toxicity sampling, flow monitoring and reporting of self-monitoring information. This new regulation specified a list of pollutants for monitoring as per the Effluent Monitoring Priority Pollutants List (EMPPL-OMOE 1987) and a set of sampling schedules for each defined industrial and municipal sector.

The EMPPL is a list of toxic pollutants that have been detected or are potentially present in Ontario municipal and industrial effluent and pose a hazard to the receiving environment. The 1988 EMPPL update (OMOE 1989) contains 266 chemicals and includes 179 parameters from the 1987 EMPPL and 87 additional parameters.

Plants which directly discharge wastewater to surface watercourses and which are subject to the MISA effluent monitoring regulations of Ontario, were required to prepare Initial Reports under the monitoring regulations. These Reports provide details on effluent monitoring equipment, wastewater flow and process information of each discharger, that monitored effluent streams during a one year information gathering period.

The content of Initial Reports is defined by two regulations made under the *Environmental Protection Act*. These are Ontario Regulation 695/88 Effluent Monitoring - General, called the General Regulation, and a regulation covering an industrial grouping or sector called the Sector Regulation. When completed, the regulations will expand the available data base on toxic substances and result in greater uniformity in reporting.

Effluent Monitoring Regulations for the nine industrial sectors were promulgated as per the schedule shown in Table 4.5. The Ministry of the Environment is now in the process of formulating effluent limit regulations for each industrial sector based on the best available technology economically achievable. It is anticipated that the Limits Regulations for the nine industrial sectors will be promulgated by 1992. The data collected under the Effluent Monitoring Regulations will be used in combination with Best Available Technology to establish these limits.

Table 4.5 MISA Monitoring Regulations Promulgation Dates.

Sector	Monitoring Regulation
Petroleum	July 1988
Organic	April 1989
Iron & Steel	May 1989
Mining	August 1989
Pulp & Paper	July 1989
Inorganic Chemicals	June 1989
Metal Casting	October 1989
Electric Power Generation	December 1989
Municipal STP	Being Revised
Industrial Minerals	December 1989

Sampling methodologies and frequencies, analytical protocols, definitions and a list of the priority pollutants are presented in the following reports:

- A Policy and Program Statement of the Government of Ontario on Controlling Municipal and Industrial Discharges into Surface Waters (White Paper) June, 1986
- The Public Review of the MISA White Paper and the OMOE's Response to It January, 1987
- The Effluent Monitoring Regulation for the Petroleum Refining Sector (Draft) July, 1987
- Effluent Monitoring Priority Pollutants List (Draft) August, 1987
- Report on the 1986 Industrial Direct Discharges in Ontario October, 1987
- Estimation of Analytical Method Detection Limits (MDL) March, 1988
- Kraft Mill Effluents in Ontario (Report by the Expert Committee members) April, 1988

- The Public Review of the Draft Effluent Monitoring Regulation for the Petroleum Refining Sector and the Ministry of the Environment's Response to It — July, 1988
- Cost Estimates and Implications of the "Effluent Monitoring - General" and "Effluent Monitoring - Petroleum Refining Sector" Regulations for Ontario Petroleum Refineries — July, 1988
- Effluent Monitoring Regulations for the Petroleum Sector — July, 1988
- Inventory and Critical Review of Laboratory Resources (Final Report) — July, 1988
- The Economic and Financial Profile of the Petroleum Refining Sector (Summary Report) — August, 1988
- Model Sewer Use By-Law — August, 1988
- Controlling Industrial Discharges to Sewers — September, 1988
- The Development Document for the Draft Effluent Monitoring Regulation for the Organic Chemical Manufacturing Sector — October, 1988
- Report on the 1987 Industrial Direct Discharges in Ontario — October, 1988
- Effluent Monitoring Priority Pollutants List - 1988 Update — March, 1989
- The Development Document for the Effluent Monitoring Regulation for the Metal Casting Sector — January, 1990
- Interim Pollution Reduction Strategy for Ontario Kraft Mills — April, 1989
- The Development Document for the Effluent Monitoring Regulation for the Electric Power Generation Sector — February, 1990

Copies of these reports are available at the MISA office.

4.1.3.1 Compliance and Enforcement

A number of enforcement options are available under the *Environmental Protection Act* to ensure compliance where an adverse effect on the environment will or is likely to occur.

Legally enforceable Control Orders may be issued to any existing plant under Section 6 of the EPA. Control Orders define tasks and compliance dates by which specific tasks must be completed.

Control Orders may require a facility to perform any of the following:

- limit a discharge;
- install necessary equipment;
- produce a contingency plan and have spill response equipment;
- provide financial assurance;
- repair/remediate damage to the environment; and
- stop operations.

There are federal regulations imposed under the *Fisheries Act* for effluents from the mining, petroleum refining, and pulp and paper sectors as well as the mercury cell chlor-alkali process. As well, the federal Policy for the Management of Fish Habitat, established under this act, has an overall objective of 'no net loss' of habitat with the goals relating to habitat conservation, development, and remediation of damaged habitat. Certificates of Approval (CofA) for sewage works are issued under the *Ontario Water Resources Act.* In the past, the CofA was an approval to install pollution control equipment with the expected effluent quality, used as the basis for design, sometimes shown in the CofA. Recently, new sewage work approvals have begun to include effluent limits which are legally enforceable, since the required performance of the treatment system is explicitly defined.

For non-compliance with legally enforceable limits, OMOE's approach is to develop an action plan to return the discharger to compliance. Such a plan could include enforcement measures, abatement negotiations or issuance of Control Orders.

For exceedence of guideline limits, regional abatement staff assess whether the exceedence caused or would likely cause impairment to the receiving waters. If so, then enforcement actions may be initiated as for non-compliant sources above. Otherwise, OMOE staff request dischargers to take voluntary abatement measures and/or Ministry staff work together with the company to eliminate the exceedences.

Remedial actions are often complex, involving problem definition, development of appropriate remedial measures, negotiation of abatement plans including public consultation, design, approval, construction and commissioning of works, and may extend over several years in some situations.

Under the EPA, offenses may result in fines to individuals of up to $5,000 plus one year in jail for a first offense, and up to $10,000 plus one year in jail for subsequent offenses. Corporations may receive penalties of up to $50,000 and $100,000 for first and subsequent offenses, respectively.

Only the exceedences of legally enforceable limits in Control Orders, Requirement and Direction, and Certificates of Approval could directly result in prosecutions under existing legislation. The guidelines in and of themselves, are not directly legally enforceable. Consequently, a separate review of guideline limit exceedences is provided.

The OMOE will continue to expect industrial dischargers to meet any numerical limits including guidelines until they are replaced by the technology based requirements of MISA being phased in for major industrial sectors over the next few years.

4.1.4 Non-Point Sources

There are limited controls under the OWRA and EPA for urban and rural/agricultural runoff. No control strategies exist for the treatment of combined sewer overflows (CSOs). However, the province has worked with municipalities to segregate sanitary and storm sewers to reduce CSOs and sewage treatment plant bypasses. The MISA program will consider abatement requirements for CSOs. Stormwater quality management is discussed in Section 4.1.4.4.

Guidelines for snow disposal and de-icing operations in Ontario require that snow dumps be located on land, remote (greater than 600 feet) from surface water, and should not seriously obstruct natural drainage or contaminate groundwater. The bulk use of de-icing compounds, other than salts, is restricted to special circumstances (e.g. airport runways). A program is underway to control and mitigate leachate from salt storage facilities.

Agriculture Canada and the Ontario Ministry of Agriculture and Food have instituted the Soil and Water Environmental Enhancement Program (SWEEP) to educate farmers on new tillage, crop rotation and soil conservation practices, and have provided soil testing services to assist in determining appropriate application rates for fertilizers and lime. The Ontario Ministry of the Environment has restricted application rates, times and contaminant levels in sewage sludges applied to agricultural land (Table 4.6).

Table 4.6 Ontario Metal Criteria for Land Application of Sewage Sludge*.

Metals	Maximum Permissible Concentration (mg/kg solids)
Arsenic	170
Cadmium	34
Cobalt	340
Chromium	2800
Copper	1700
Mercury	11
Molybdenum	94
Nickel	420
Lead	1100
Selenium	34
Zinc	4200

* These values are for all aerobic sewage sludge and all dried and dewatered anaerobic sewage sludge. Other regulations apply for liquid anaerobic sewage sludge.

Ontario Ministry of Agriculture and Food's Land Stewardship II Program provides incentives for planned conservation systems and environmental protection measures. The program has four major aspects: 1) an emphasis on conservation farm planning, 2) extension, education and technology transfer field staff, 3) grants to: farmers who adopt conservation practices or build soil conservation or environmental protection structures as part of their conservation farm plan, and to organizations for on-farm demonstrations and evaluations or conservation promotion and education and 4) farmer-led administration.

The Farm Pollution Advisory Committee (FPAC) is comprised of four farmers appointed by the Minister of the Environment under Section 3(1) of the *Environmental Protection Act*. The FPAC's role is to advise the Minister about whether in a specific situation, animal waste is being handled and disposed of in accordance with "normal farming practice", and thereby not impacting the quality of nearby water bodies. This advise is crucial to the Minister due to exemptions in the EPA for agriculture.

4.1.4.1 Shipping

Pleasure crafts are controlled by Ontario's Boating and Marine Regulations, pursuant to the *Environmental Protection Act*. Small boats must be fitted with holding tanks to contain wastewater, which are emptied by special pumps at marinas. Non-waste water is not regulated under provincial regulations. Commercial shipping activities that may affect water quality are regulated under the *Canada Shipping Act*. These regulations are discussed in Section 4.2.3.1.

The provincial *Dangerous Goods Act* reiterates the measures outlined under the federal *Transportation of Dangerous Goods Act*. Provincial Guidelines for Environmental Protection Measures at Chemical Storage Facilities recommend preventive procedures consistent with those of the Manufacturing Chemists Association. For liquids, this would entail diked containment at a location away from piping and drainage systems, the compatibility of liquids stored in proximity and the use of safety alarms. Gases and volatile liquids are stored more safely in appropriately vented roof tanks with water deluge systems to capture any escaping soluble compounds. All drainage and leakage from storage areas should be collected and treated prior to disposal.

4.1.4.2 Spills

Part IX of the *Environmental Protection Act*, referred to as the "Spills Bill", deals with spills of pollutants into the natural environment from or out of a structure, vehicle or other container, that are abnormal in light of all circumstances, and which cause, or are likely to cause, adverse effects. The "Spills Bill" establishes notification requirements, responsibilities and compensation mechanisms, in addition to other factors. The Ontario Spills Action Centre, whose origin was spawned by the "Spills Bill", coordinates the Ministry's response network, working closely with the Canadian Coast Guard, police and fire departments, and other reporting centres, as well as downstream water users in Ontario and Michigan.

In the event of a major spill to the St. Clair River, the Ministry obtains preliminary estimates of concentrations and durations from the source. Using a model designed specifically for the St. Clair River, the concentration and duration of the pollutant is predicted at downstream water intakes in Ontario and Michigan. If the Provincial Water Quality Objectives (PWQOs) and/or Drinking Water Quality Objectives (DWQOs) are exceeded at the intakes the users are advised and withdrawal of water from the St. Clair River may be terminated while the plume passes. For chemicals for which the Ministry does not have established water quality objectives, the Ministry will refer to standards or objectives enforced by any other agency worldwide (see Section 4.1.2), in consultation with experts in the Drinking Water Section of the Ministry's Water Resources Branch. Since few short-term exposure limits exist for most compounds, the Ministry has relied on the more common long-term exposure limits for guidance in such incidents.

4.1.4.3 Sediment Quality

The quality of sediments is assessed against contaminant concentrations established in the 1978 Revised Guidelines for Open Water Disposal of Dredged Spoils (Table 4.7). The OMOE allows open water disposal of dredged materials with contaminant levels less than established guidelines, providing existing water uses are not affected. Any other suspected contaminants in the sediments are evaluated on a case-by-case basis.

Contaminated sediments constitute a significant environmental concern in the Great Lakes Basin, and existing guidelines are under review by most agencies. Special advisory groups, such as the Polluted Sediment Subcommittee under the Canada-Ontario Agreement, have been established to review sediment guidelines and assessment criteria, to evaluate dredging activities and in-place remedial options, and to provide expert advice on infilling practices. Under the EPA the OMOE can order the removal of contaminated sediments.

Biologically-based Provincial Sediment Quality Guidelines for contaminant concentrations in sediments are currently under development. The draft sediment quality guidelines are also presented in Table 4.7 (March 1991 version). They will replace the open water disposal of dredged material guidelines once approved. These guidelines have been designed to address the significance of contaminants in *in-situ* sediment as opposed to the dredged material open water disposal criteria which only incidently provide general guidance on environmental protection. The sediment quality guidelines were developed specifically to protect those aquatic organisms that are directly impacted by contaminated sediment, i.e., benthic organisms. The three levels of ecotoxic effects are:

No Effect Level - level at which no toxic effects have been observed on aquatic organism;
Lowest Effect Level - level of contamination which can be tolerated by the majority of benthic organisms; and
Severe Effect Level - level at which pronounced disturbance of the sediment dwelling community can be expected.

Table 4.7 **Ontario MOE Guidelines for Dredged Material Disposal in Open Water and the draft Provincial Sediment Quality Guidelines (mg/kg, unless otherwise noted).**

Parameter	**Ontario MOE Dredged Material Disposal Guidelines**	**Provincial Sediment Quality Guidelines[1]**		
		No Effect Level	**Lowest Effect Level**	**Severe Effect Level[2]**
Total Phosphorus	1000	-	600	2000
Total Kjeldahl Nitrogen	2000	-	550	4800
Ammonia	100	-	-	-
Volatile Solids (Loss on Ignition)	60,000	-	-	-
Oil & Grease	1,500	-	-	-
Arsenic	8	-	6	33
Cadmium	1	-	0.6	10
Chromium	25	-	26	110
Cobalt	50	-	-	-
Copper	25	-	16	110
Cyanide	0.1	-	-	-
Iron	10,000	-	2%	4%
Lead	50	-	31	250
Manganese	-	-	460	1100
Mercury	0.3	-	0.2	2
Nickel	25	-	16	75
Silver	0.5	-	-	-
Zinc	100	-	120	820
Total PCBs	0.05	0.01	0.07	530
Total PAHs	-	(2)	(11,000)	
Hexachlorobenzene	-	0.01	0.02	24
Aldrin	-	-	0.002	8
BHC	-	-	0.003	12
α-BHC	-	-	0.006	10
-BHC	-	-	0.005	21
γ-BHC	-	0.0002	(0.003)[a]	(1)[b]
Chlordane	-	0.005	0.007	6
Total DDT	-	-	0.007	12
op+pp-DDT	-	-	0.008	71
pp-DDD	-	-	0.008	6

Table 4.7 (cont'd)

Parameter	Ontario MOE Dredged Material Disposal Guidelines	Provincial Sediment Quality Guidelines[1]		
		No Effect Level	Lowest Effect Level	Severe Effect Level[2]
pp-DDE	-	-	0.005	19
Dieldrin	-	0.0006	0.002	91
Endrin	-	0.0005	0.003	130
Heptachlor	-	0.0003	-	-
Heptachlor Epoxide	-	-	0.005[a]	5[b]
Mirex	-	-	0.007	130
Total Organic Carbon (TOC)	-	-	1%	10%

Lowest Effect Levels and Severe Effect Levels for organic parameters are based on the 5th and 95th percentiles, respectively of the Screening Level Concentration (SLC) unless noted otherwise: [a] -10% SLC. [b] -90% SLC.

( ) denotes tentative guidelines.

\- no guideline developed.

1 values < 10 have been rounded to one significant digit, values greater than 10 have been rounded to two significant digits.

2 Numbers in this column (organic parameters only) are to be converted to bulk sediment values by multiplying by the actual TOC concentration of the sediments (to an maximum of 10%), e.g., analysis of a sediment sample gave a PCB value of 30 ppm and a TOC of 5%. The value for PCB in the Severe Effects column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 X 0.05 = 26.5 ppm as the Severe Effect Level guidelines for that sediment. The measured value of 30 ppm is then compared with this bulk sediment value and is found to exceed the guideline.

Dredging

Most dredging in Canada is done by the federal government and there is no formal regulatory approval process. Although overall agency responsibility for dredging projects depends upon the project type and location, all projects involve review by several agencies. Remedial dredging projects in Canadian AOCs have been limited thus far to a project in Windemere Basin in Hamilton Harbour.

The Canadian Federal Departments of Fisheries and Oceans, and Transport Canada, as well as some local Harbour Commissions are typical proponents of dredging operations at various locations in the Great Lakes; however, Public Works Canada provides project management services for these Federal departments. These projects fall under the federal Environmental Assessment and Review Process (EARP) which is undertaken and assessed by the project proponent. EARP has two major stages:

1. As part of an initial assessment stage of the EARP, the proponent would seek advice from the various federal agencies, ports and harbour commissions, and in Ontario, OMOE and OMNR. The project is assessed for possible environmental concerns, taking into account information and comments from these agencies. If it is determined that the environmental effects are not significant, then the project can proceed.

2. If the initial assessment indicates that there may be environmental problems, the project may be referred to the Federal Environmental Assessment Review Office for a major environmental assessment. Thus far, no dredging projects in Ontario have gone through this process.

Federal legislation is expected in the near future to improve EARP's public consultation process and strengthen requirements. Environment Canada is reviewing Ontario's newly proposed sediment quality guidelines, and is likely to adopt them as interim guidelines and ask for federal agencies to abide by them.

Under the federal Great Lakes Program, Request for Proposals (RFPs) are being developed to solicit projects to demonstrate state-of-the-art technologies for the remediation of contaminated sediments. This effort will be coordinated with the U.S. EPA's Assessment and Remediation of Contaminated Sediments (ARCs) program so as not to duplicate efforts.

At present, there is no single specific policy in Ontario for the management of contaminated sediments in circumstances other than those where dredging is proposed. Most dredging projects in Ontario are undertaken for navigational purposes and are subject to a variety of federal and provincial legislation. Although Federal Departments are not obligated to seek formal approval of their undertakings under provincial laws, it has been an established Federal policy to meet to the fullest possible extent requirements established under provincial statutes, regulations and guidelines.

Proposals are evaluated on a case-by-case basis, using OMOE bulk chemical guidelines, to determine whether the dredged material requires confined disposal. These guidelines will soon be replaced with the biologically-based, sediment guidelines described above. In addition, guidelines for the classification of dredged material requiring disposal as hazardous waste are also under development. In addition to an evaluation of sediment quality, the proposed dredging, transport, and disposal methods are examined along with the timing of the project. Project approval generally requires that certain mitigative measures are undertaken and that monitoring be carried out during and after the dredging operation.

4.1.4.4 Stormwater

The Interim Stormwater Quality Guidelines (Draft) have been developed jointly by the Ontario Ministries of the Environment (OMOE) and Natural Resources (OMNR) to address the need for stormwater quality management in new developments in developing areas in Ontario. These guidelines are consistent with the approach outlined in the Urban Drainage Design Guidelines (1987a). The purposes of these interim guidelines are:

a) To provide guidance to OMOE and OMNR staff in the review of planning documents and development proposals.
b) To provide guidance to OMOE and OMNR staff in the requirements, evaluation and approval of stormwater management facilities for water quality control for developments proposed under the *Planning Act*.
c) To provide municipalities with OMOE's information requirements for the review of planning documents and planning proposals for stormwater management facilities for stormwater quality control for new developments.
d) To provide guidance to proponents for stormwater management for water quality control.

The Interim Stormwater Quality Guidelines are intended to be reviewed and updated on an ongoing basis. Offices of the OMOE and OMNR request and review quality components of stormwater management proposals for new development under the *Planning Act*. OMOE has the legislative authority to review and approve stormwater treatment works under Section 24 of the *Ontario Water Resources Act*.

The Water Management Goals, Policies and Implementation Procedures of the Ministry of the Environment (Ministry of the Environment, 1984) require conservation and remedial measures for the control of nonpoint sources such as stormwater discharges if they are shown to cause or contribute significantly to violations of the Provincial Water Quality Objectives.

The interim stormwater guidelines are applicable to any new development in developing areas reviewed under the *Planning Act*. Application of the guidelines will depend on the sensitivity of the waterbody that the stormwater is being discharged to. These guidelines could also provide direction in the review of undertakings subject to the *Environmental Assessment Act*, other legislation or other agency programs.

The development criteria contained in the Interim Stormwater Quality Control Guidelines can be implemented within legislative, policy and administrative procedures already available to the two ministries. Therefore, it represents no new policy initiatives or development design techniques, rather, it formalizes how established design and planning tools can be applied and how the two ministries can coordinate their activities and effectively relate to other agencies.

Related Programs and Studies

The Ontario Urban Drainage Management Program (UDMP) is designed to encourage good drainage planning and apply good practices in stormwater management, including preparation of Watershed Plans, Master Drainage Plans, and Stormwater Management Plans; major and minor drainage systems in design, and erosion and sediment control during construction. Two documents have been released by the Ontario Urban Drainage Implementation Committee in support of the UDMP: Urban Drainage Design Guidelines, 1987, and Guidelines on Erosion and Sediment Control for Urban Construction Sites, 1987.

The UDMP deals mainly with stormwater quantities. Control of stormwater pollution in new developments is envisioned mainly as erosion and sediment control during construction. The UDMP is voluntary at this time. This position will be re-evaluated after sufficient experience is gained.

OMOE's Pollution Control Planning (PCP) Program funds the abatement of pollution in existing urban areas. This PCP Program is carried out on an "as needed basis", separately from urban drainage planning such as Master Drainage and Stormwater Management Plans. The PCP Program does; however, provide input to urban drainage planning activities where multi-source water quality problems (especially wet weather sources) exist.

4.1.5 Wetlands and Shorelands

Physical alterations to Ontario Crown lake, river and stream beds and adjacent to shorelands are regulated by the *Public Lands Act* (1980). This act provides for a work permit and associated review process which, among other things, allows authorities to ensure critical fish and wildlife habitat will not be destroyed or harmed by the work proposed. Fisheries habitat such as spawning, nursery and feeding sites, as well as migration routes, is afforded more direct protection by means of the *Fisheries Act*. This is a federal statute which is enforced by both provincial and federal agencies.

Ontario provincial agencies and the federal government have entered into a Habitat Management Agreement whereby fish habitat, which includes many wetland areas, is to be protected and opportunities for rehabilitation are considered where feasible. A draft wetlands policy is currently under review and is expected to be in place soon. It will increase recognition and protection of the most significant classes of wetlands in the province.

4.1.6 Solid, Liquid & Hazardous Waste Controls

Solid and hazardous waste programs are implemented by the provincial government mainly under the *Environmental Protection Act*. The EPA Waste Management-General Regulations describe the classification and approval of waste disposal sites and waste management systems. Standards for the location, maintenance and operation of a landfill site are outlined, including measures to be taken for the collection and treatment of contaminants for the prevention of water pollution. These include locating the landfill site above, or isolated from, the maximum ground water level to protect the aquifer, and allowing sufficient distance from water sources to prevent contamination, unless all leachate is collected and treated. The implementation of the Waste Management General Regulations and related policies are summarized in "The Incorporation of the Reasonable Use Concept into the Ground Water Management Activities of the Ministry of the Environment." In addition to landfill record-keeping requirements, an expanded manifest system was recently implemented under EPA Regulation 309 to ensure the registration of wastes by generators, and proper handling, shipping and disposal by carriers and receivers. The Hauled Liquid Industrial Waste Disposal Sites Regulations (EPA Regulation 808) prescribes standards for the operation and maintenance of all Ministry-approved industrial sites. One requirement is that ground water and surface water quality in and around the site shall be regularly monitored.

The Guidelines for the Treatment and Disposal of Liquid Industrial Wastes in Ontario applies to Ministry-approved waste treatment and disposal processes or sites (except those covered by other regulations or guidelines). These Guidelines list various industrial wastes and recommend a corresponding treatment and disposal process.

The provincial Waste Management PCB Regulations require owners or generators of PCB wastes to keep records regarding the waste's nature, quantity, storage method and location on-site (or transportation offsite), while awaiting final resolution of the waste. Standards for the location, maintenance and operation of mobile PCB destruction facility waste disposal sites are included in the Mobile PCB Destruction Facilities Regulation. Two such companies operate in Ontario. Maximum point of impingement levels are imposed on air emissions of PCBs, chlorinated dibenzodioxins, and chlorinated dibenzofurans. All solid wastes generated must be disposed of at a certified waste disposal site.

Ontario Regulation 303, under *Ontario Environmental Protection Act*, prohibits disposal of any liquid industrial waste into the Detroit River Group geological formation. It also prohibits the disposal of brines into the Detroit River Group within eight kilometres (five miles) of the St. Clair River. Oil field brine is exempt from this regulation. All brine disposal wells into the Detroit River Group greater than eight kilometres from the St. Clair River are gravity-feed only. These prohibitions came into effect in 1974.

4.1.7 Pesticides

The provincial *Pesticides Act* (1980) prohibits, in general, the discharge or emission of pesticides that would cause or be likely to cause damage to the environment, animal or plant life, or human health greater than the impairment that would necessarily result from the proper use of the pesticide. A license to carry out exterminations and other requirements such as application methods, permits, safety precautions, and use restrictions for specific pesticides are outlined in the Pesticides (General) Regulations.

The Ontario Ministry of Agriculture and Food's Food Systems 2002 is a comprehensive program to assist growers to cut their use of pesticides in half by the year 2002. The program has three components: 1) research - to develop and implement non-chemical alternatives using high technology and biotechnology, 2) education - to inform farmers about new methods for the best use of pesticides and 3) field delivery (extension) - to assist farmers in adopting new pest-control technology.

The Integrated Pest Management Program, which provides advice on pesticide use to farmers, and the Ontario Pesticide Education Program, a program of study on the safe handling and application of pesticides for vendors and growers, have both been enhanced under Food Systems 2002.

4.1.8 Air Quality

Air quality in Ontario is regulated under Regulation 308 of the *Ontario Environmental Protection Act*. Under this regulation, the Ministry of Environment may prepare an "Air Pollution Index" to express the relative levels of air pollution. As an index level is approached or exceeded, the Ministry of Environment, in consultation with the Ministry of Health, may order curtailment of the operation of sources of air pollution. The Regulation also identifies the maximum concentration of contaminants at a point of impingement from a source of contaminant, other than a motor vehicle. The maximum concentrations are outlined in Appendix 4.2.

Ontario MOE, in conjunction with the Michigan DNR, the Lambton Industrial Society, and representatives from Wayne County, Michigan, prepare a yearly summary of transboundary air contaminant movement. Monitoring is most extensive for ozone, sulfur dioxide, carbon monoxide, total suspended particles and particle-bound lead. Less extensive monitoring is conducted for oxides of nitrogen, hydrocarbons, reduced sulfur and other constituents of the particulate matter. Ontario MOE also conducts ambient air quality monitoring in Sarnia, Windsor and Sault Ste. Marie, measuring similar parameters as above. A report is issued annually.

The Ontario MOE Air Resources Branch conducts studies of long range transportation and deposition to the Great Lakes, specifically for toxic contaminants. There are two permanent air monitoring stations involved in this study area; one near Lake Huron and one near Lake Erie.

The LIMA (Lambton Industrial Meteorological Alert) Regulation (Ontario Regulation 151/81) focuses on the effect of Sarnia industries on air quality. If levels of sulfur dioxide in the Sarnia area exceed 0.7 ppm, the Regional Director of OMOE can declare an alert, and order designated industries to reduce emissions, and operations, if necessary. Four monitoring stations are involved in this: two in Sarnia, one in Corunna and one in Port Huron, Michigan.

4.1.9 Fish Consumption Advisories

Ontario has established concentration limits for boneless skinless fillets of dorsal muscle based on guidance from Health and Welfare Canada and the *Federal Food & Drug Act* (Table 4.8). Ontario has used these limits to establish restricted consumption guidelines. Fish contaminant data is not generally evaluated on the basis of mean or average contaminant values. Rather a geometric regression analysis of length versus contaminant concentration is done to determine at what size a particular sample collection analyzed individual may exceed a particular Health and Welfare Canada criterion. At the size where the concentration exceeds the criterion, restricted consumption is advised (or no consumption, in the cases of women of child-bearing age and children under 15 years of age) for fish in that size category and above. Mercury also has a "No Consumption" guideline, above which no consumption is advised for all populations. Ontario publishes its consumption advisories for various fish species, sizes and locations annually in "Guide to Eating Ontario Sport Fish".

While there are no Federal guidelines for the levels of copper, nickel, zinc, cadmium, manganese, chromium, arsenic, and selenium in fish, they are usually not detected in trace levels in Ontario sport fish. Based on the guidelines for levels in other food stuffs, there is no need to suggest restrictions on the consumption of fish. This is also the case for hexachlorobenzene.

Table 4.8 Canadian Legal Limits for contaminants in commercial fish (mg/kg).

Parameter	Concentration in Edible Portion H&WC(1)
Total Mercury	0.5
PCBs	2.0
Dieldrin	0.1*
DDT + metabolites	5.0
Endrin	0.1*
Heptachlor/H. epoxide	0.1*
Lindane	0.1*
Mirex	0.1
2,3,7,8-TCDD	0.000020**
Lead	1.0***
Toxaphene	0.1*
Chlordane	0.1
Malathion	0.1
Parathion	0.1

(1) U.S. EPA. 1989. Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish: A Guidance Manual. September 1989. EPA-503/8-89-002. Washington D.C.

* Legal limit for agricultural chemicals in general.
** Currently under review.
***In areas where lead is considered to be in the organic form.

4.1.10 Drinking Water Objectives

The Ontario Drinking Water Objectives (ODWOs) are used to assess the suitability of surface water supplies for treatment and public consumption. The ODWOs specify that three types of drinking water quality objectives shall be recognized; Maximum Acceptable Concentrations, Interim Maximum Acceptable Concentrations, and Maximum Desirable Concentrations. These are described below. Drinking water quality objectives are provided in Appendix 4.3.

Maximum Acceptable Concentration (MAC)

This term is used for limits above which there are known or suspected adverse health effects. The presence of a substance in drinking water at a level in excess of its maximum acceptable concentration shall be grounds for rejection of the water unless effective treatment is available. The length of time the maximum acceptable concentrations can be exceeded without injury to health will depend on the nature and concentration of the contaminant; however, no drinking water can be permitted to exceed these limits continuously. The MACs are developed under the authority of the *Ontario Water Resources Act*. They are based on known or suspected human health effects and may be made into enforceable standards through inclusion in Certificates of Approval. The proposed *Safe Drinking Water Act*, however, would make them enforceable standards.

Interim Maximum Acceptable Concentration (IMAC)

This term is used to describe limits for substances of current concern with known chronic effects in mammals and for which there are no established maximum acceptable concentrations. Although toxicological, epidemiological and health data are available for such substances the data are subject to public and scientific debate before agreement on a maximum acceptable concentration. The IMAC will generally be a conservative value subject to change as more precise information becomes available. When a substance is detected at a concentration above its IMAC, it will signal the need for more sampling and investigation. Requirements for corrective action will be on a case-by-case basis.

Aesthetic Objectives

This term (formerly 'Maximum Desirable Concentration') is used for limits on substances which, when present at concentrations above the objectives, are either aesthetically objectionable to an appreciable number of consumers or may interfere with good water quality control practices. These limits are not legally enforceable; however, should not be exceeded whenever a more suitable supply or treatment process is, or can be made available at a reasonable cost.

Application of Limits

A water supply system is defined as including the works and auxiliaries for collection, treatment, storage and distribution of the water from the source of supply to the free-flowing outlet of the ultimate consumer.

The limits apply to all water supply systems which provide water for domestic purposes and serve more than five private residences or are capable of supplying water at a rate greater than 0.5 litres per second (OWR/Act, 1980). Although a water supply serving five or fewer private residences is excluded from the application of the limits, it is desirable that the quality of water from these supplies should not be inferior to that supplied to the public in general.

The establishment of a limit should not be regarded as implying approval of the degradation of a high quality supply to the specific level. The limits have been derived from the best information currently available; however, the development of drinking water objectives is an ongoing process. Scientific knowledge of the complex inter-relationships that determine water quality continues to increase, as does the understanding of the physiological effects of the substances present in water. Also, new chemical substances are continually introduced into the environment, many of which may contaminate drinking water supplies. Therefore, it may be necessary to revise the established limits or determine limits for other substances as additional and more significant data become available.

4.2 CANADA

4.2.1 Environmental Legislation Relevant to the Great Lakes

Under the *Canadian Constitution Act* of 1867, the provinces and territories have been given authority over most natural resources and water quality except on federal property, international issues and in other specific areas of federal jurisdiction. However, the federal government acts in an advisory capacity on many issues by recommending guidelines to the provinces. Table 4.9 lists the significant legislation from which specific environmental regulations and programs are derived.

Table 4.9 Canadian Environmental Legislation.

Canada Legislation	Media or Activity Addressed												
	A	B	C	D	E	F	G	H	I	J	K	L	M
Fisheries Act *	1	3	1	1	1	3	3			3			3
Canada Water Act	2	2	3									2	
Canadian Environmental Protection Act (CEPA)*	3	3	3	1	1	1	1	2	1		1	2	
Food and Drug Act													1
*Canada Shipping Act**	3	3	3								1		
Transportation of Dangerous Goods Act (TDGA)	3	3	3			1					1		
Pest Control Products Act (PCPA)							1			3			
Environmental Contaminants Act (repealed)*						1							

* Significant Act elaborated on in the text.

<u>Key to Codes:</u>

A: Ambient Surface Water and Ground Water Quality and Management
B: Sediment Quality and Management
C: Biota Quality, Habitat Management and Habitat Protection
D: Industrial Point Source Discharge Control
E: Municipal Point Source Discharge Control
F: Solid and Hazardous Waste Management
G: Pesticide Manufacture and Management
H: Urban Runoff and Combined Sewer Overflow Management
I: Air Point Source Discharge and Ambient Air Quality Control
J: Agricultural Land Management
K: Spills and Shipping Activities
L: Drinking Water Quality Control and Management
M: Fish Consumption Guidelines or Advisories

1: Legislation is responsible for legally enforceable standards and/or has direct authority over the media or activity.
2: Legislation provides non-enforceable guidance or authority over media or activity.
3: Legislation is not directly applicable to the media or activity, but media/activity may be impacted by execution of its legislative mandate.

4.2.2 Point Sources

The *Fisheries Act* is the most significant Federal Statute for the protection of fish habitat from chemical pollution. Promulgated in 1977, the habitat protection provisions of the Act provide for the protection of fish and fish habitat from disruptive and destructive activities. Section 36(3) of the Act provides comprehensive powers to protect fish, fish habitat and human use of fish by prohibiting the discharge of deleterious substances to Canadian Fisheries waters and is legally enforceable when an impact on fish or fish habitat can be shown. A deleterious substance is defined by Section 36(3) as any substance or water that has been processed or changed which, if added to the system, would degrade the quality of the water so that it is rendered deleterious to fish or fish habitat.

Federal effluent regulations and guidelines for various industrial sectors are promulgated under Section 36 of the *Fisheries Act*, and are based on the application of best practicable technology. In general, regulations set national effluent limitations that apply to new and expanded plants, and guidelines set minimum acceptable standards that apply to existing plants. To date, *Fisheries Act* regulations and guidelines have been promulgated for the pulp and paper, mining, petroleum refining, metal finishing, chlor-alkali and mercury sectors. Some of these regulations and guidelines are currently being updated. Only one of these regulations, the Petroleum Refinery Liquid Effluent Regulations and Guidelines (1974), has applicability to the St. Clair River. These regulations and guidelines limit pH, oil and grease, phenols, sulphide, ammonia-nitrogen, total suspended matter and acute toxicity in discharges per production rate.

Federal guidelines for effluent quality and wastewater treatment at federal establishments apply to all effluents discharged from landbased establishments under the direct authority of the federal government, excluding vehicles and vessels. These guidelines have been developed and are administered by Environment Canada, and are revised and amended periodically to reflect new developments in technology and changing circumstances. Effluent guidelines for wastewater from federal facilities are to be equal to or more stringent than provincial standards. The guidelines contain both general and specific limits, and apply primarily to domestic-type effluents. General limits describe, qualitatively, the effluent quality (e.g., it should be free from materials harmful to aquatic life). Specific limits set numerical concentrations for conventional pollutants (Table 4.10).

Table 4.10 Canadian and Ontario Effluent Guidelines.

PARAMETER	Ontario Industrial Effluent Objectives	Canadian Municipal Effluent Objectives
BOD5 mg/L	15	20
Suspended Solids mg/L	15	25
Oil and Grease mg/L	15	15
Ammonia-Nitrogen mg/L	10	-
Fecal Coliforms MF/100 ml	-	400
pH SU units	5.5-9.5	6-9
Total Phenols mg/L	0.020	0.02
Total Phosphorus mg/L	-	1
Total Residual Chlorine mg/L	-	0.5
Cadmium mg/L	0.001	-
Chromium mg/L	1.0	-
Copper mg/L	1.0	-
Lead mg/L	1.0	-
Mercury mg/L	0.001	-
Nickel mg/L	1.0	-
Tin mg/L	1.0	-
Zinc mg/L	1.0	-

The *Canada Water Act* provides for water quality management authorities under agreement with the province of Ontario. The Canada-Ontario Agreement Respecting Great Lakes Water Quality (COA) covers water quality objectives, monitoring requirements and shared cost programs. This agreement is a public contract between the federal and provincial government in which those governments agree to undertake and coordinate activities within their jurisdiction to fulfil the GLWQA requirements.

All but Section 9 of the *Environmental Contaminants Act* has been repealed and replaced by the *Canadian Environmental Protection Act*, 1988 (CEPA). Under this legislation, the federal government restricts the phosphorus content in detergents to 5 percent by weight (expressed as phosphorous pentoxide) or 2.2 percent by weight (expressed as elemental phosphorous). In addition, the act identifies specific chemicals subject to regulation. Chemicals which are currently prohibited from commercial, manufacturing or processing uses include certain chlorobiphenyls (PCBs), dodecachloropentacyclodecane, certain polybrominated biphenyls, chlorofluoro-carbons and polychlorinated terphenyls. In addition, draft regulations have been prepared under this act for pulp and paper mills to prohibit the commercial, manufacturing or processing uses of certain chlorinated dioxins and furans as well as to regulate their maximum concentrations in products and environmental releases. Regulations can also be developed for other chemicals if the chemical is demonstrated to be toxic.

Municipal effluent objectives have been recommended to the provincial governments who, in turn, have established minimum treatment requirements for their municipal facilities by limiting the concentration of total phosphorus in their effluents.

4.2.3 Non-Point Sources

The Soil and Water Environmental Enhancement Programme (SWEEP) has been instituted by Agriculture Canada and the Ontario Ministry of Agriculture and Food to educate farmers about new technologies, the benefits of crop rotation, and other soil conservation practices. New agricultural practices such as these are being promoted in an effort to reduce contaminant and nutrient loadings and soil erosion to adjacent surface water.

4.2.3.1 Shipping

The *Canada Shipping Act* controls pollution from ships. Regulations have been passed under this Act directed at shipping activities that may impact water quality, including the control of the discharge of oil, vessel wastes and shipboard wastes. Under these regulations, the vessel may be fitted with a patent sewage treatment plant, which treats sewage to secondary standards, and reduces both suspended solids and the five day biological oxygen demand to 50 mg/L. The alternative requires the vessel to be fitted with a holding tank which must be emptied on shore. In both cases, a 90 percent reduction occurs, and the remaining treated effluent is disinfected.

The protection of the environment and human health from chemical spills during transportation or storage is regulated by both the provincial and federal governments. The *Transportation of Dangerous Goods Act* prescribes safety requirements, standards and safety marks on all means of transport across Canada.

4.2.4 Hazardous Waste Control

Under the *Canadian Environmental Protection Act*, Environment Canada has the authority to control the manufacture, transport, use, disposal, import and export of chemicals and wastes (e.g. PCBs, PCB products and Mirex). The main thrust of this Act is the creation of 1) the Domestic Substances List, which will eventually be a list of all chemicals manufactured and imported to Canada, including toxicity data; 2) the Priority Substances List, which is a list of chemicals under active study by Environment Canada due to concerns over their toxicity; and 3) the Toxic Substances List, which is a list of all chemicals deemed a danger to the environment and for which regulations must be promulgated. The Toxic Substances List includes PCBs, polybrominated biphenyls, chlorofluorocarbons, polychlorinated terphenyls, asbestos, lead, mercury and vinyl chloride.

4.2.5 Pesticides

The principal statute controlling pesticides in Canada is the *Pest Control Products Act* (PCPA) administered by Agriculture Canada. The PCPA sets out regulations regarding the registration, safety and manufacturing of control products to protect human health, and the host plant, animal or article.

Registering pesticides and other control products under the PCPA in Canada provides additional information on registration and labelling requirements such as warning symbols and content description. Under the PCPA, the Minister of Agriculture Canada can establish independent Boards of Inquiry to advise him/her on whether pest control products should be registered. For example, in the recent case of alachlor, a Board of Inquiry was established and then disbanded after making their recommendation to the Minster.

Nonregulatory programs at the federal level include a pest management scheme that may reduce reliance on pesticides. The principal approach to reducing reliance on chemical pest control is known as integrated pest management, and is currently being researched by Agriculture Canada.

4.2.6 Air Quality

The *Canadian Clean Air Act* was repealed and replaced by the Canadian Environmental Protection Act. CEPA regulates atmospheric emissions of toxic chemicals including asbestos (from mines and mills), lead (from secondary smelters), mercury (from chlor-alkali mercury plants) and vinyl chloride (polyvinyl chloride plants). CEPA can also be used to regulate any toxic substance which is released into the air and which creates, or may reasonably be anticipated to create, air pollution in other countries.

Air quality objectives have also been established as a guide in developing programs to reduce the damaging effects of air pollution. The national objectives assist in establishing priorities for reducing contaminant levels and the extent of pollution control needed, provide a uniform yardstick for assessing air quality in all parts of Canada, and indicate the need for and extent of monitoring programs. The Maximum Acceptable Level is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being. The Maximum Desirable Level defines long-term goals and provides a basis for an anti-degradation policy in unpolluted areas of the country. The Maximum Tolerable Level denotes concentrations of air contaminants that require abatement without delay to avoid deterioration of air quality to a level that endangers the prevailing Canadian lifestyle or, ultimately, pose substantial risk to public health.

4.2.7 Fish Consumption Advisories

The federal *Food and Drug Act* authorizes Health and Welfare Canada to establish tolerances for chemical substances in fish and fishery products intended for human consumption. These criteria have been adopted by the Province of Ontario, and are discussed in Section 4.1.9.

4.2.8 Great Lakes Water Quality Working Group

A federal interdepartmental Great Lakes Water Quality Working Group has been established to encourage interdepartmental cooperation in government programs which are designed to help restore and secure the chemical, physical and biological integrity of the Great Lakes. More specific objectives of the Working

Group include ensuring and preserving an adequate water quality and quantity for use by wildlife, fish and other organisms, and humans.

4.3 MICHIGAN AND UNITED STATES

4.3.1 Water Quality Standards

Existing and future uses of Michigan surface waters are protected under the Michigan Water Resources Commission Act, 1929 PA 245, as amended. The Act, under Sections 2 and 5, provides for the Part 4 Rules of the Water Resources Commission (WRC) which are Michigan's Water Quality Standards (WQS). These Standards (1) establish water quality requirements applicable to the Great Lakes, their connecting waterways, and all other surface waters of the state, (2) protect public health and welfare, (3) enhance and maintain the quality of water, (4) protect the state's natural resources, (5) meet the requirements of the federal Clean Water Act, (6) are consistent with the U.S.-Canada Great Lakes Water Quality Agreement, and (7) are legally enforceable.

The WQS, filed with the Secretary of State on November 14, 1986, were approved by the U.S. EPA pursuant to Section 303 of the Clean Water Act. Therefore, Michigan WQS supersede the U.S. EPA criteria for Michigan surface waters. This discussion focuses on the Michigan WQS. Copies of the Water Resources Commission Act and the Water Quality Standards are available upon request from the Michigan Department of Natural Resources (MDNR), Surface Water Quality Division.

Michigan WQS are currently undergoing a triennial review, as required by the Clean Water Act. No substantive changes to the standards are proposed at this time. Therefore, the following discussion will also be applicable once the new standards are approved. As part of the triennial review, a comparison was made of Michigan's WQS and the Great Lakes Water Quality Agreement (GLWQA) objectives. The WQS were found, overall, to be consistent with the goals and specific objectives of the GLWQA. The report of the comparison is provided in Appendix 4.4.

The Water Quality Standards designate specific uses as a minimum basis for which all Michigan surface waters must be protected. These uses include agricultural, industrial, and public water supply; use by warmwater fish, other indigenous aquatic life, and wildlife; navigation; and partial body contact recreation (e.g. fishing and boating). Additional protection is afforded to waters that are protected for use by coldwater fish; this includes the Great Lakes, their connecting waters (except for the Keweenaw Waterway), and all waters designated by the Michigan Department of Natural Resources (MDNR) as trout streams or trout lakes. All waters of the state are designated for, and shall be protected for, total body contact recreation (e.g. swimming) from May 1 to October 31. The WQS also specify that all waters be protected for the most restrictive of all applicable designated uses. The standards also define parameters and criteria levels necessary to protect a waterbody for its designated uses. Specific WQS are stated which set forth minimum and maximum levels for certain water quality parameters (Table 4.11).

Toxic substances are controlled under a narrative rule (Rule 323.1057) specifying that they shall not be present in Michigan waters at concentrations that are, or may become, injurious to the public health, safety or welfare; plant and animal life; or the designated uses of those waters. Rule 57 is applicable to the 256 chemicals and classes of chemicals listed on the 1984 Michigan Critical Materials Register; the priority pollutants and hazardous chemicals in the Code of Federal Regulations; and any other toxic substances determined by the WRC to be of concern at a specific site.

Specific, allowable levels of toxic substances may be established by the MDNR under Rule 57. Specific guidelines for the development of allowable levels of toxic substances in surface water have been developed and are available upon request from the MDNR, Surface Water Quality Division. Following these

Table 4.11 Summary of Michigan Water Quality Standards.

Parameter	Limit
Turbidity Color Oil films Solids (floating, suspended or settleable) Foams Deposits	Waters of the state shall not have any of these unnatural physical properties in quantities which are or may become injurious to any designated use.
Total dissolved solids (TDS)	The addition of any dissolved solids shall not exceed concentrations which are or may become injurious to any designated use. In no instance shall they exceed 500 mg/L monthly average or 750 mg/L maximum for any waters of the state.
Chlorides	A maximum of 125 mg/L monthly average is allowed for waters of the state designated as public water supply sources, except for the Great Lakes and their connecting waters where chlorides shall not exceed a 50 mg/L monthly average.
Hydrogen Ion Concentration (pH)	6.5-9.0 in all waters of the state. Any artificially induced variation in natural pH shall remain within this range and shall not exceed 0.5 units of pH.
Taste and Odor	Waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair or may impair their use for a public, industrial or agricultural water supply source or which impair the palatability of fish.
Toxic Substances	Substance specific as determined by Rule 57. (See text for description, and Table 4.12 for Rule 57(2) levels.)
Radioactive Substances	Standards prescribed by the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency.
Phosphorus	1.0 mg/L as a maximum monthly average for effluent discharges.
Nutrients	In addition to the maximum phosphorus discharge levels allowed, nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended and floating plants, fungi or bacteria, which are or may become injurious to the designated uses of the waters of the state.
Fecal Coliform	All waters of the state shall contain not more than 200 fecal coliforms per 100 milliliters as determined on the basis of a geometric average of any series of 5 or more consecutive samples taken over not more than a 30-day period. This concentration may be exceeded if such concentration is due to uncontrollable nonpoint sources. The WRC may suspend this limit from November 1 through April 30 upon determining that designated uses will be protected.
Dissolved Oxygen (DO)	A minimum of 7 mg/L in all Great Lakes and connecting waterways, and lakes and streams designated for coldwater fish. In all other waters a minimum of 5 mg/L shall be maintained.

Table 4.11 cont'd

Parameter	Limit
Temperature	No heat load which would warm receiving waters at the edge of the mixing zone more than 3 degrees Fahrenheit above existing natural water temperature for the Great Lakes and their connecting waters; 2 degrees Fahrenheit for coldwater streams; and 5 degrees Fahrenheit for warmwater streams.

guidelines, concentrations of toxic substances in surface water necessary to protect aquatic life, wildlife and human health (life cycle safe and cancer risk) are calculated. The most restrictive concentration is used as the allowable level in surface water. Allowable levels of toxic substances in surface water are given in Table 4.12. Allowable levels for certain toxic substances may be water body specific. For example, the toxicity of some heavy metals is dependent on the hardness of the water. Therefore, allowable levels for those metals are also dependent on water hardness.

Portions of waterbodies can be designated as mixing zones which are defined as areas where point source discharges are mixed with the receiving water. However, there are several requirements that apply to the water quality within the mixing zone. As a minimum restriction, waters may not be acutely toxic to fish or fish food organisms anywhere within the mixing zone. Exposures in mixing zones may not cause deleterious effects to populations of aquatic life or wildlife, and the mixing zone shall not prevent the passage of fish or fish food organisms in a manner which would result in adverse impacts on their immediate or future populations.

The Water Quality Standards are minimally acceptable water quality conditions. Ambient water quality should be equal to or better than the Water Quality Standards at least 95 percent of the time. Antidegradation requirements exist for waters that have better water quality than the established Water Quality Standards, or that is needed to protect existing uses. The Antidegradation Rule of the WQS states that waters may not be lowered in quality unless it is determined by the WRC that degradation of the these waters will not impair designated uses or be unreasonable and against public interest in view of the existing conditions.

The rules also declare that Michigan waters which do not meet the Water Quality Standards shall be improved to meet those Standards. Where the water quality of a certain waterbody does not meet the Water Quality Standards as a result of natural causes or conditions, further reduction of water quality is prohibited.

4.3.1.1 Great Lakes Initiative

The Great Lakes Initiative (GLI) is a joint effort by the U.S. EPA and the eight Great Lakes states to coordinate activities under the Federal Clean Water Act (CWA) to meet the goals of the Governors Great Lakes Toxic Substances Control Agreement, and to achieve the objectives of the Great Lakes Water Quality Agreement (GLWQA). The GLI will provide a basis for proceeding toward the long term goal of virtual elimination of the discharge of toxic substances to the Great Lakes, and for negotiating Great Lakes programs and water quality objectives with Canada under the GLWQA.

The GLI will develop numeric water quality criteria for a select list of chemicals and a narrative procedure for developing water quality criteria for other chemicals. In both cases, the water quality criteria will include criteria for the protection of human health, wildlife and aquatic life. The GLI will also address issues such as mixing zones, procedures for establishing water quality-based effluent limits in permits, biomonitoring requirements, pollution prevention, and antidegradation. The expected outcome of the GLI is to develop guidance which will be used by the Great Lakes States in reviewing and revising their water quality standards. The projected completion date of the GLI is late 1991.

Table 4.12 Michigan Allowable Levels of Toxic Substances in Surface Water. January 15, 1991 Update (MDNR 1991).

Chemical Name	Rule 57(2) Allowable Level ($\mu g/L$)	Basis[1]	Comments
Arsenic	184.0	ACV	
Cadmium & Inorganic Salts	0.41	ACV	2
Chromium & Inorganic Salts	48.10	ACV	2
Copper & Inorganic Salts	10.72	ACV	2
Cyanide	4.0	ACV	
Lead & Inorganic Salts	2.88	ACV	2
Nickel & Inorganic Salts	33.34	ACV	2
Selenium & Inorganic Salts	20.0	TLSC	
Silver & Inorganic Salts	0.1	ACV	
Zinc & Inorganic Salts	49.57	ACV	2
Molybdenum	800.0	TLSC	
Paraquat	16.0	ACV	
PCB	0.00002	CRV	3
Formaldehyde	171.0	TLSC	3
DDT	0.0023	CRV	3
Phenol, 2,4-dinitro	9.8	ACV	
Carbon tetrachloride	20.0	CRV	3
Chlordane	0.00053	CRV	
Lindane	0.097	CRV	3
Phenol, 4-chloro-3-methyl	4.4	ACV	
Dieldrin	0.0000315	CRV	
Aniline	4.0	ACV	3
Acetone	500.0	TLSC	
Chloroform	43.0	CRV	3
Hexachloroethane	13.0	CRV	3
Benzene	60.0	TLSC	3
Ethane, 1,1,1-trichloro	117.0	ACV	
Bromomethane	11.0	ACV	
Vinyl chloride	3.1	TLSC	3
Methylene chloride	59.0	ACV	5
Ethylene oxide	56.0	CRV	3
Bromoform	65.0	ACV	

Table 4.12 cont'd

Chemical Name	Rule 57(2) Allowable Level ($\mu g/L$)	Basis[1]	Comments
Bromodichloromethane	24.0	TLSC	
Ethylene, 1,1-dichloro	2.6	CRV	3
Heptachlor	0.002	CRV	
Hexachlorocyclopentadiene	0.5	ACV	
Isophorone	860.0	ACV	
Propane, 1,1-dichloro	64.0	CRV	
Ethane, 1,1,2-trichloro	65.0	CRV	3
Trichloroethylene	94.0	ACV	3
Acrylamide	900.0	TLSC	
Ethane, 1,1,2,2-tetrachloro	30.0	TLSC	3
Pentachlorophenol = pH 8.1	20.23	ACV	4
2,4,6-Trichlorophenol	1.5	CRV	3
Dinoseb	0.80	ACV	4
Naphthalene	29.0	ACV	
Benzidine, 3,3-dichloro	0.06	CRV	3, 5
Benzidine	0.0399	CRV	3, 5
Silvex	21.3	HLSC	
Acetic Acid, 2,4-dichlorophenoxy	46.7	ACV	
Benzene, 1,2-dichloro	7.0	ACV	
Phenol, 2-chloro	10.0	ACV	
Ethylbenzene	30.0	ACV	
Styrene	19.0	CRV	3
Benzene, 1,4-dichloro	15.0	CRV	3
Phenol, 4-chloro	9.3	ACV	
Ethylene dibromide	1.10	CRV	3, 5
Acrolein	3.0	ACV	
Ethane, 1,2-dichloro	560.0	CRV	3
Acrylonitrile	2.20	CRV	3, 5
Toluene	100.0	ACV	
Chlorobenzene	71.0	ACV	
Phenol	110.0	HLSC	
Bis(2-chloroethyl)ether	4.20	CRV	3
Bis(2-chloroethoxy) methane	4.60	TLSC	

Table 4.12 cont'd

Chemical Name	Rule 57(2) Allowable Level ($\mu g/L$)	Basis[1]	Comments
Hexachlorobenzene	0.0018	CRV	3
Benzene, 1,2,4-trichloro	22.0	HLSC	
Phenol, 2,4-dichloro	37.74	ACV	4
1,4-dioxane	2000.0	CRV	3
Chlorodibromomethane	29.0	TLSC	
Tetrachloroethylene	16.0	CRV	3
Ethylene, t-1,2-dichloro	300.0	ACV	
Benzene, 1,3-dichloro	179.0	ACV	
1,2,3,4-Tetrachlorobenzene	0.76	HLSC	
Xylene	59.0	ACV	
Tetra n-butyl ammonium bromide	140.0	TLSC	
2,3,7,8-TCDD	0.000000014	CRV	3, 5
Di-n-propyl formamide	63.0	TLSC	
Mercury, methyl	0.0013	HLSC	
Vanadium	3.73	TLSC	
Ammonia, unionized (coldwater)	20.0	ACV	
Ammonia, unionized (warmwater)	50.0	ACV	
Fluorides (soluble fluorides)	2000.0	TLSC	
Chlorine	6.0	ACV	
Hydrogen sulfide	0.55	ACV	
DBNPA	4.0	ACV	
Chromium, hexavalent	2.0	ACV	
bis(chlorobutyl)ether	60.0	TLSC	

Comment Codes

1 - ACV = Aquatic Chronic Value
TLSC = Terrestrial Life-cycle Safe Concentration
CRV = Cancer Risk Value
HLSC = Human Life-cycle Safe Concentration

2 - Rule 57(2) Level is based on a water hardness of 100 mg/L (as $CaCO_3$).

3 - This chemical is regulated as a carcinogen. The Rule 57(2) Level is not necessarily based on its 1 in 100,000 cancer risk value.

4 - Rule 57(2) Level is based on a pH of 8.0.

5 - Professional Judgement was used - minimum data not available.

4.3.2 Point Source Discharge Permits

Effluent requirements for wastewater discharged to Michigan surface waters are established in National Pollutant Discharge Elimination System (NPDES) permits. The NPDES permitting system was established for the entire nation in 1972 by the federal Water Pollution Control Act ("Clean Water Act"; PL 92-500). NPDES permits are required for all point source discharges of pollutants under the Clean Water Act and the Michigan Water Resources Commission Act.

Operation of the NPDES permitting program was delegated to Michigan by the U.S. EPA in October 1973. Effluent limits are required to be at least as stringent as the National effluent guidelines. The Michigan WRC is responsible for issuance or denial of NPDES permits. Effluent requirements and other conditions of a permit are recommended to the WRC by MDNR staff, with assistance from other state departments including the Michigan Department of Public Health. The general responsibility for enforcement of NPDES permit requirements lies with the Department of Natural Resources. The Michigan Department of the Attorney General works with the MDNR as needed to enforce NPDES permit requirements.

The NPDES permits are complex legal documents. Each permit contains the following general parts: specific authorization to discharge wastewater; effluent limitations and monitoring requirements; special conditions applicable to the particular discharge; special conditions applicable for certain general types of programs, such as industrial pretreatment program requirements, management requirements for sludges and other residuals, combined sewer overflow requirements, etc; and the general requirements applicable to all permits, such as what to do in emergency situations, operator certification, permit modification procedures, etc.

The permit is the primary legal document which states under what conditions a discharge is authorized. There are, however, two other areas that are critical to the success of the NPDES program. Prior to permit issuance, water quality studies, surveillance, and monitoring on both the point source discharges and the receiving water body are conducted as needed to determine what limitations should be placed in the permit. This includes both chemical and biological (toxicity tests, biological surveys) characterization. The facility desiring a permit to discharge is required to submit a permit application detailing the treatment process and discharge characteristics (e.g. flow, chemical characteristics). After permit issuance, enforcement followup is needed to ensure compliance with the permit.

One goal of the Clean Water Act is to move toward zero discharge of pollutants by use of treatment technology-based standards, and requiring that minimum receiving Water Quality Standards be achieved. Treatment technology-based discharge standards and effluent limitations based on the Water Quality Standards are determined for a given discharger. Since both must be met, the permits contain the more stringent of the two limits.

Treatment technology based standards are promulgated by the U.S. EPA based on the category of the industrial or municipal facility. National standards have been developed for 26 industrial categories, and involve over 125 toxic pollutants commonly discharged by these industries. Treatment technology-based standards are promulgated for direct discharges to lakes and streams, and for indirect discharges to surface water via sanitary sewer systems. Discharges to storm sewers which do not receive subsequent treatment are considered direct discharges. As treatment technologies improve, these federal standards are expected to become more restrictive in order to progress toward the goal of zero discharge.

Treatment technology-based effluent limitations (TTBELs) are often collectively referred to as the "Effluent Limit Guidelines". When Effluent Limit Guidelines do not exist for a certain discharge, either because none of the industrial categories cover the specific type of operation, or because Effluent Limit Guidelines have not been promulgated for the category yet, treatment technology-based limits must be determined. In this case, the "best professional judgement" of the permit writer is used to determine what the treatment technology-based effluent limits should be for the specific facility. The primary factors that are considered in establishing best professional judgement limits are the type of waste and pollutants, and available technology for a specific discharge. Other factors which may also be considered include costs and benefits of installing a certain treatment technology, and the age of the facility and equipment.

Water quality based effluent limits are determined following the WQS and associated guidelines to ensure that Water Quality Standards are achieved in the receiving waters. The WQS apply at flows greater than the design (drought) flow of the receiving streams. The design flow is the most restrictive of the 12 monthly 95 percent exceedence flows, a statistically-derived, low-flow value that occurs very infrequently. The applicable flows at which Water Quality Standards apply may be different than the 95 percent exceedence flow if the WRC determines that a more restrictive design flow is necessary, or that seasonal design flows may be granted. All Water Quality Standards for conventional pollutants apply after mixing with the design flow. For toxic substances, not more than one-fourth of the receiving water design flow is used for mixing. This is applied to both chemical specific values and biological toxicity endpoints determined through standardized toxicity tests.

Each surface water discharge permit application is reviewed to ensure that appropriate water quality-based control requirements are incorporated in the NPDES permit. Potential contributors are considered in a wasteload allocation process used by MDNR to establish these water quality-based control requirements. Site specific determinations are made based upon existing data and design conditions for the discharge and the receiving water. Water quality-based effluent limits are proposed when there is the reasonable potential that a point source discharge will cause or contribute to an excursion above any WQS. Water quality based effluent limits are determined by mathematical models used to simulate the substances in the receiving waters. For most toxic pollutants, a simple materials balance is used for calculations. When there are multiple dischargers to a single receiving waterbody, the assimilative capacity must be allocated among them.

Another consideration when issuing permits is "Antibacksliding". This concept has been contained in federal regulations for several years, and was incorporated into the federal Clean Water Act by the 1987 amendments. It is a complex concept which, roughly translated, means that limitations in a previous permit will not be made less stringent when the permit is reissued. Exceptions to the "antibacksliding" rule include when the permittee was unable to achieve the previous permit limits, and when production is increased.

NPDES permits have a maximum life of 5 years. When permits expire, they are reviewed and reissued. A complete cycle of reissuance occurs every 5 years, with approximately 20 percent of the permits being reissued each year. Under Michigan law, an expired permit remains in effect until a new permit is issued or denied.

4.3.2.1 Industrial Pretreatment Program

An important component of the NPDES permitting program is the Industrial Pretreatment Program (IPP). The IPP was developed in recognition of the fact that many industrial operations discharge their wastewater to municipal wastewater treatment plants (WWTP). This industrial wastewater may contain pollutants in concentrations that can interfere with the operations of the WWTP, damage equipment, destroy the bacteria required in the treatment process, pass through the system untreated, or contaminate sludge. To prevent these problems, any Michigan municipality that operates a wastewater treatment plant and receives a discharge from an industrial categorical discharger or an industrial discharger whose discharge could cause any of the following four conditions must develop and implement an industrial pretreatment program:

1. Physical damage to the sewers or the treatment process

2. Inhibition of the WWTP processes

3. Pass-through of pollutants which could cause problems in the receiving stream or result in an NPDES permit violation

4. Accumulation of pollutants in the sludge which could cause problems during its disposal

The IPP contains details as to how the industrial wastewater will be treated prior to discharge to the municipal collection system, establishes local limits and outlines monitoring and compliance requirements. The industrial discharger must also comply with applicable federal treatment technology-based limitations.

The municipality that operates the WWTP is responsible for developing, implementing and enforcing the local IPP. The IPPs are reviewed by the municipality on an annual basis to ensure that compliance with all applicable policies and regulations is maintained. The State reviews and approves the local IPP in accordance with established State and federal IPP regulations. The State functions in an "oversight" role to the local IPP Control Authority, and the U.S. EPA functions in an "oversight" role to the State. An NPDES permit is issued to the municipality for its discharge to the surface water.

4.3.2.2 Combined Sewer Overflows

Combined sewer overflows (CSOs) constitute a serious environmental concern because they constitute a discharge of raw sewage and can pose public health concerns. NPDES permits are required for all CSOs. The permits contain date certain schedules for development of CSO corrective programs. The corrective program established in the NPDES permit is a phased approach intended to provide flexibility for individual communities to develop site-specific corrective programs.

Phase I of the CSO corrective program requires operational improvements of the existing system to minimize overflows, sampling and other monitoring requirements to establish a strong database on the existing system, and construction of interim CSO control projects where feasible. Under Phase I, all CSO communities are required to notify the MDNR when there is a discharge of raw sewage to surface waters from CSOs. The MDNR will notify the local public health agency when appropriate. The health agency will issue appropriate advisories. Phase I also requires development of a final program to eliminate or adequately treat CSOs. The final program must also contain a fixed-date schedule to achieve the maximum feasible progress in accomplishing these corrections, taking into account technical and economic considerations.

Phase II is the implementation of the final program under subsequent NPDES permits. The schedule developed under Phase I will be incorporated into the NPDES permit, and the permittee required to proceed with implementation. The permits require that final programs provide for elimination or adequate treatment of CSOs. This will be accomplished on a case-by-case basis with professional staff of the Department working closely with municipalities to define appropriate corrective programs.

4.3.2.3 Compliance and Enforcement

NPDES permits are required under the Clean Water Act and the Michigan Water Resources Commission Act for all point source discharges to surface waters of the State. Any violation of a permit condition, compliance schedule or effluent limit specified in the permit, or a point source discharge to surface water without a permit is a violation of the Clean Water Act and the Michigan Water Resources Commission Act. Such violations of the Acts may be subject to civil and/or criminal action for injunction relief, substantial monetary penalties, and reimbursement for environmental damages.

A permit violation may be detected by the MDNR through routine review of compliance schedules and discharge monitoring reports (DMR) prepared by the permittee, and various types of inspections by MDNR staff. Violations may also be directly reported to MDNR. Upon recognition of a permit violation or a violation of related sections of the CWA or the Michigan Water Resources Commission Act, an appropriate compliance/enforcement action is taken. The compliance/enforcement response will be timely, and appropriate for the nature and severity of the violation.

The MDNR is developing an Enforcement Management System (EMS) to assure that all dischargers are treated fairly, and to consistently enforce the NPDES program as required by the Clean Water Act and the Michigan Water Resources Commission Act. The EMS is a tool to assist professional staff in assuring that timely and appropriate enforcement actions are taken. Guidance is provided in the EMS to assist the state in assessing the magnitude and severity of the violation, and a range of enforcement responses that would be appropriate for the violation. The EMS also establishes a system for identifying priorities and directing the flow of enforcement actions based on these priorities and available resources. The measure of effectiveness of an enforcement response is whether and how expeditiously the noncompliant source is returned to compliance.

4.3.2.4 Stormwater

The federal Clean Water Act as amended in February 1987 contains language which specifically addresses the regulation of stormwater discharges (Section 405). The Act specifies that stormwater discharges will be regulated through the NPDES permit program.

The amendment states, in part, that no stormwater permits shall be required prior to October 1, 1992, except for the following: (1) currently permitted stormwater outfalls; (2) stormwater outfalls from industrial plant sites; (3) municipal storm sewer systems serving more than 250,000 population; (4) municipal storm sewer systems serving between 100,000 and 250,000 population; and (5) any point source of stormwater causing water quality violations.

The Clean Water Act, as amended, provides specific dates for U.S. EPA action regarding regulation development for several of these excepted categories. The U.S. EPA published the final regulations concerning stormwater discharges on November 16, 1990. The regulations defined what facilities would be considered industrial stormwater dischargers and established November 16, 1991 as the date by which these facilities must apply for a stormwater discharge permit. The regulations also established a two part application process for municipalities. Part I for municipalities with populations greater than 250,000 is due November 16, 1991 and part II is due November 16, 1992. For municipalities with populations between 100,000 and 250,000, part I is due on May 18, 1992 and part II on May 17, 1993.

The regulations establish application requirements that for industrial facilities include sampling, topographic maps, impervious surface area estimates and spill history. Applications for municipalities covered by the regulations will include sampling, topographic maps and legal authority of the municipality.

Industrial permits will contain technology and water quality-based requirements. Municipal permits will require the development and implementation of comprehensive stormwater management programs to identify and eliminate illicit discharges to storm sewer and to reduce the discharge of pollutants in stormwater to the maximum extent practicable. Compliance with stormwater permits will be required three years after permit issuance.

4.3.3 Critical Materials and Wastewater Report

A Critical Materials and Wastewater Report must be filed annually with the MDNR by all businesses that discharge wastewater to lagoons, deep wells, the surface of the ground, surface waters, septic tanks, or municipal sewer systems according to the Michigan Water Resources Commission Act. The types of wastewater that must be reported are process water, non-contact cooling water, condenser water, commercial laundry and commercial car wash water. Sanitary wastewater which is discharged to any system other than a municipal sewer or septic tank must also be reported.

The Critical Materials and Wastewater Report sets forth the nature of the business, a list of materials used in or incidental to its manufacturing process, including by-products and waste products, and the estimated volume of wastewater discharged. The materials which must be reported appear on the Critical Materials Register (CMR) as compiled by the MDNR with the advice of a technical advisory committee. The most recent CMR, published October 1, 1988, contains 284 chemicals. The information provided in the report may be used for purposes of pollution control including the determination of parameters to be limited by the NPDES permit.

4.3.4 Nonpoint Sources

The regulation and control of nonpoint sources of pollution in Michigan is the responsibility of a number of state, federal and local agencies, under a variety of programs and legislative directives. Until recently, however, the state lacked a comprehensive, coordinated plan to address nonpoint sources of pollution.

In November 1988, Michigan submitted a four year management plan to the U.S. EPA to address pollution problems caused by nonpoint sources. This management plan, and an assessment of the extent of surface and groundwater contamination due to nonpoint sources (also submitted in November 1988), are required under Section 319 of the Clean Water Act of 1987.

Michigan's Nonpoint Source Management Plan and Assessment Report have been approved by EPA. The Management Plan meets the requirements of the Clean Water Act and qualifies Michigan for federal funding to reduce nonpoint source pollution. Michigan received 1.3 million dollars through Section 319 of the Clean Water Act in Fiscal Year 1990. These funds are being used to implement programs in the Nonpoint Source Management Plan.

Solving nonpoint source pollution problems in Michigan will require the implementation of abatement programs through the cooperative efforts of federal, state and local agencies. Nonpoint source program implementation can occur on either a statewide or watershed basis. One of Michigan's priorities is to emphasize implementation of nonpoint source programs on a watershed basis. Approximately 30 watershed projects are either in the planning or implementation phases throughout the state. A number of statewide programs including development of best management practices, hydrologic analysis, construction site erosion control, technical assistance and information/education programs are underway.

4.3.4.1 Erosion

Soil erosion from construction sites is regulated through the Soil Erosion and Sedimentation Control Act, 1972 PA 347. The Act requires permits for all earth changing activities within 500 feet of a lake or stream, or that are likely to disturb an acre or more of land area. The program is administered by the Department of Natural Resources through local designated enforcement agencies.

Agricultural soil erosion is controlled through the use of conservation practices on farms. The Soil Conservation Service and local Soil Conservation Districts assist landowners in developing conservation practices for their property.

4.3.4.2 Spills

The prevention of and response to spills of oil and polluting materials (salt and any material listed on the Critical Materials Register, in solid or liquid form) to waters of the state are addressed in the Part 5 Rules of the Michigan Water Resources Commission Act, as amended. These rules require Pollution Incident Prevention Plans for spills prevention and cleanup for oil storage facilities and facilities that store, handle, discharge, manufacture, receive or process polluting materials. The rules also require that spill containment equipment and adequate personnel be available at sites where oil is on-loaded or off-loaded through a conduit to a vessel on the waters, and at sites adjacent to a watercourse where oil is stored and handled. Further, the rules specify that adequate surveillance be maintained at all times such that a spill can be immediately detected. When a spill is detected, the rules require immediate response. Under these rules, storage and use areas for oil, salt, and other polluting materials must be adequately diked or contained to prevent escape of spilled materials to groundwater and surface water both directly and indirectly (e.g. through sewers and drains). If a spill occurs from a vessel or a facility, a report must be filed with the WRC outlining the cause, discovery, and actions taken to remove the spilled material from the water.

The Oil and Gas Act, PA 61 requires operation of production and disposal wells in such a manner as to prevent the escape of oil, gas, saltwater, brine or oil field wastes which would pollute, damage or destroy freshwater resources.

The MDNR operates a Pollution Emergency Alert System (PEAS). A toll free telephone line (1-800-292-4706) is maintained for the reporting of suspected pollution incidences. MDNR staff investigate and respond to emergency spill occurrences, and coordinate actions with other agencies. A spill of any quantity of any material is reportable under PEAS.

There are several federal Acts and regulations that pertain to spills prevention and response. Federal regulations under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) identify "hazardous substances", notification requirements in the event of a spill and repotable quantities. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) established under CERCLA concerns the release of oil and hazardous materials into navigable waters. The Clean Water Act also prohibits the discharge of oil in harmful amounts, and requires owners of facilities which present a threat of an oil release to surface water to prepare a Spill Prevention Control and Countermeasure (SPCC) plan. The Solid Waste Disposal Act requires transporters to take appropriate action, and to notify the National Response Center in the event of a spill. The Emergency Planning and Community Right-to-Know Act of 1986 requires that any facility that produces, uses or stores chemicals regulated under this Act participate in emergency planning procedures for spills. Cleanup policy for PCB spills is contained in the Toxic Substances Control Act.

In the event of an unauthorized release of pollutants to the U.S. waters of the Great Lakes or connecting channels, the U.S. Coast Guard would have the lead responsibility in investigating and responding to the incident. Michigan and Ontario have established an emergency notification protocol to be used in the event of an accidental release to the water or air that may have transboundary impacts. This protocol is discussed in Section 4.5.

4.3.4.3 Ballast Water Exchange

The exchange of ballast water from commercial ships has not been regulated as of this writing. However, the need for such regulation has been recognized due to nuisance conditions caused by the unintentional introduction of exotic aquatic species such as the sea lamprey, and more recently the zebra mussel, via the discharge of ballast water from commercial ships. In March, 1990 proposed legislation was introduced which would initiate a national ballast exchange program, and coordinate and manage regulatory programs for the control of aquatic nuisance species. The draft legislation would institute a voluntary ballast exchange program for two years, after which the program would become mandatory for the Great Lakes. The proposed legislation is expected to be passed in 1990 (S2244, Non-indigenous Aquatic Nuisance Act, and HR 5390, Aquatic Nuisance Prevention and Control Act).

4.3.4.4 Contaminated Sediments

Chemical contamination of freshwater sediments has the potential to adversely affect aquatic life. However, there are, as of this writing, no federal or state sediment quality standards, or guidelines on how to identify sediments that may be detrimental to aquatic life or to assess the severity of the effect. The U.S. EPA is currently investigating several approaches to developing sediment quality criteria (e.g. equilibrium partitioning, apparent effects threshold, tissue residue). Draft criteria have not yet been proposed. The U.S. EPA's Interim Guidelines for the Disposal of Great Lakes Harbor Sediments" of 1977 have been used as a yardstick of contamination. The guidelines are not biologically based, however, and are not indicative of potential effect levels.

Assessing the effects of chemical contamination on aquatic life is complicated by the many variables that affect the toxicity and availability of the contaminants. Therefore, the state is pursuing an assessment protocol that includes a combination of biological field surveys, chemical and physical analyses of sediments, and sediment toxicity tests. MDNR currently conducts biological field surveys, and chemical and (limited) physical analyses of sediments. Work is underway at the MDNR Aquatic Toxicity Evaluation Laboratory (ATEL) to develop and validate procedures for conducting sediment toxicity tests and culturing the required test organisms. ATEL staff is focusing on a solid phase chronic toxicity test with *Chironomus tentans*, an interstitial acute toxicity test with *Daphnia magna* and an interstitial chronic test with *Ceriodaphnia dubia*.

A great deal of information is still required on how to interpret the results of laboratory tests with respect to instream responses, and how to integrate results of the various investigations to determine whether a sediment related problem exists. There are many ongoing efforts in both the regulatory and scientific communities to answer these questions, and Michigan has taken an active interest in a number of them. Probably the most comprehensive of these efforts is the Assessment and Remediation of Contaminated Sediments (ARCS) Program which is administered by the U.S. EPA Great Lakes National Program Office (GLNPO). This is a five year study and demonstration project relating to the control and removal of toxic substances from the Great Lakes. The program was authorized in Section 118 (c)(3) of the Clean Water Act as amended in 1987. The primary objective of the ARCS program is to develop guidance on the assessment of contaminated sediment problems and the selection and implementation of remedial actions. Guidance documents and case study final reports are expected to be completed by October 1993.

4.3.5 Navigational Dredging and Sediment Disposal

Dredging projects in Michigan are evaluated by MDNR and the Michigan Department of Transportation following the International Joint Commission (IJC) Guidelines presented in "Guidelines and Register for Evaluation of Great Lakes Dredging Projects," Report of the Dredging Subcommittee, January 1982 and the U.S. EPA "Interim Guidelines for the Disposal of Great Lakes Harbor Sediment" of 1977. All dredging projects proposed in Michigan are subject to review and certification under Sections 401(a) and 404(t) of the Federal Clean Water Act, PL 92-500. Through the certification process Michigan addresses water quality impacts which may occur during the proposed dredging and disposal, impacts to fish and wildlife, recreational use concerns and scheduling of the proposed operation.

Water quality concerns may also be addressed under Rule 92 of Michigan's Water Quality Standards. This rule provides that the Water Resources Commission may determine that a dredging activity results in unacceptable impacts on designated uses, and that the Water Quality Standards are applicable during and subsequent to the dredging activity. In these cases, the "401 water quality certification", issued under Section 401 of the Clean Water Act, would reflect any restrictions on the dredging and/or disposal operation. Acting under the authority of Rule 92, the Commission determined that the use of overflow dredging in areas with contaminated sediments (not suitable for open water disposal due to contamination) results in unacceptable impacts on designated uses. Each dredging project where the use of a hopper dredge is proposed is evaluated to determine whether the use of hopper overflow should be prohibited due to sediment contamination. Evaluation of the St. Clair River maintenance project conducted by the Corps of Engineers found that overflow dredging should not be restricted. However, it was recommended that the decision be re-evaluated when new data become available.

Dredging permits and 401 Water Quality Certifications may also be required under the Inland Lakes and Streams Act, 1972 PA 346, and the Great Lakes Submerged Lands Act, 1955 PA 247, as amended. All 346/247 permit applications are reviewed with respect to existing sediment contaminant data, and all sites are visited by MDNR personnel regardless of the degree of contamination. Projects proposed in areas with known sediment contamination are reviewed by the MDNR Surface Water Quality Division. Sediment sampling and analysis and/or project modification may be required prior to permit issuance.

The disposal method for dredged sediment is determined following an evaluation of the sediment type, contaminant type and concentration, potential beneficial uses of the material to be dredged, and availability of disposal sites. The U.S. EPA Interim Guidelines for the Disposal of Great Lakes Harbor Sediment, 1977 (Table 4.13) are used as a preliminary indicator as whether the sediments are suitable for open water disposal, or require confinement. Dredged sediments may be suitable for various types of upland disposal depending on the presence of leachable substances and the hazard to the environment. The Solid Waste Management Act, 1978 PA 64, as amended, and the Michigan Environmental Response Act, 1982 PA 307, as amended, and the administrative rules adopted pursuant to these Acts govern upland disposal options.

The Michigan Hazardous Waste Regulations, under the Hazardous Waste Management Act, 1979 PA 64, as amended, and 40 CFR 261 (1986) may be applied to sediments when disposal in a landfill is proposed. Under these regulations, the person(s) doing the dredging may be requested to conduct an extraction procedure toxicity (EP toxicity) and/or the toxicity character leaching procedure (TCLP) to determine if the material is "hazardous". If the material is classified as "hazardous" under the Resource Conservation and Recovery Act (PL 94-586), disposal in a licensed hazardous waste landfill is required.

4.3.6 Wetlands and Shorelines

Wetlands protection and management in Michigan is governed by ten state and two federal statutes that include a variety of specific protection and permitting programs. The state statutes are listed and briefly described in Table 4.14. The two federal statutes, the Clean Water Act of 1972 and the Rivers and Harbors Act of 1899, deal mainly with navigation issues. The Clean Water Act regulates the discharge of dredged or other fill material into navigable waters and their adjacent wetlands. The U.S. EPA is currently developing a Great Lakes Basin wetlands strategy to guide the State and Federal jurisdictions on the protection and management of wetlands.

The most recent and comprehensive of the state laws is the Wetland Protection Act, 1979 PA 203. This act provides for the preservation, management, protection and use of wetlands; requires permits to alter wetlands; and provides penalties for illegal wetland alteration. Act 203 established a state policy to protect the public against the loss of wetlands and make explicit determinations on the benefits wetlands provide. It also established a permit program to regulate some activities in wetlands that are above the ordinary high water marks of lakes and streams. Additionally, Act 203 explicitly authorized more stringent and broader regulation of wetlands by local governments, and set up a cooperative process for the sharing of information and expertise between the MDNR and local governments.

Activities in wetlands contiguous to waterbodies are regulated without regard to the size of the wetland because of the close relationship these areas have to surface waters. Non-contiguous wetlands, however, are regulated by permit only if they are greater than five acres in size. In counties of less than 100,000 people, activities in non-contiguous wetlands are not regulated until a wetland inventory is completed. The MDNR

Table 4.13 U.S. EPA Interim Guidelines for the Disposal of Great Lakes Harbor Sediments, 1977.

PARAMETER	NONPOLLUTED	MODERATELY POLLUTED	HEAVILY POLLUTED
Volatile Solids	5%	5% - 8%	8%
COD	40000	40000 - 80000	80000
TKN	1000	1000 - 2000	2000
Oil & Grease (Hexane Solubles)	1000	1000 - 2000	2000
Lead	40	40 - 60	60
Zinc	90	90 - 200	200
Ammonia	75	75 - 200	200
Cyanide	0.10	0.10 - 0.25	0.25
Phosphorus	420	420 - 650	650
Iron	17000	17000 - 25000	25000
Nickel	20	20 - 50	50
Manganese	300	300 - 500	500
Arsenic	3	3 - 8	8
Cadmium	*	*	6
Chromium	25	25 - 75	75
Barium	20	20 - 60	60
Copper	25	25 - 50	50
Mercury			1
Total PCB **			10

NOTE: all values in mg/kg dry weight unless otherwise noted

* lower values not determined

** Pollutional classification of sediments with total PCB concentration between 1.0 and 10.0 mg/kg dry weight determined on case-by-case basis.

can also regulate some activities in wetlands anywhere in the state, regardless of size, if they are determined to be essential to the preservation of natural resources and the landowner has been so notified by the Department.

The Shorelands Protection and Management Act provides for the designation of protected environmental areas along Michigan's Great Lakes shoreline that are important for the preservation and maintenance of fish and wildlife. Environmental areas covered by the Act are usually wetlands or marshes, although some are upland areas or islands. The Act applies to designated property that lies up to 1,000 feet landward of the ordinary high water mark of the Great Lakes or a connecting waterway, and those lands bordering other waters affected by levels of the Great Lakes. The Act does not apply to wetland areas already protected in national parks. Currently, 295 miles of Great Lakes or connecting waters shoreline have been designated as protected environmental areas. This is 9.0 percent of Michigan's 3,288 coastal shoreline miles. Fifty-two miles of protected environmental areas border Lake Superior, 85 are on Lake Michigan, 140 border Lake Huron, 6 are along the Detroit River, and 12 are located on Lake Erie.

Table 4.14 Summary of State Statutes Impacting Wetland Protection and Management in Michigan.

Statute	Description
Goemaere-Anderson Wetland Protection Act, 1979 PA 203	Recognizes wetland values; requires permit for many activities in wetlands.
Inland Lakes & Streams Act, 1972 PA 346	Requires permit for dredging, filling and construction activities in inland lakes and streams and associated wetlands below the ordinary high water mark.
Great Lakes Submerged Lands Act, 1955 PA 247	Requires permit for construction activities in Great Lakes and connecting waters.
Michigan Environmental Protection Act, 1970 PA 127	Prohibits any conduct which is likely to pollute, impair, or destroy a lake, stream or wetland, unless certain public interest conditions are met.
Shorelands Protection and Management Act, 1970 PA 245	Regulates environmental areas (primarily wetlands) along the Great Lakes.
Soil Erosion and Sedimentation Control Act, 1972 PA 347	Requires permit based on soil erosion control plan (issued locally with MDNR oversight) for earth change activities which disturb one or more acre or are within 500 feet of a lake or stream.
Natural Rivers Act, 1970 PA 231	Regulates land use along designated natural rivers through state and local zoning based on corridor management plans.
Subdivision Control Act, 1968 PA 288	Requires approval of the Water Resources Commission for any subdivision plat containing lots in the flood plain, and additional review by MDNR for any subdivision plan involving land abutting a lake or stream.
Administrative Procedures Act, 1969 PA 306	Governs the promulgation of administrative rules for state statutes, and defines the appeal process followed when permit applications under various statutes are denied.
Water Resources Commission Act, 1929 PA 245	Creates a Water Resources Commission to regulate state water resources. The Commission promulgates water quality standards and regulates discharges to state waters and related floodplains. Requires a permit to alter a flood plain.

Wetland water quality is determined by characteristics and conditions different from those used to evaluate the quality of lakes and streams. In general, natural wetlands are characterized as having very shallow water with abundant vegetation, high organic bottom deposits, and the periodic absence of oxygen throughout the water and bottom sediments (Kadlec and Kadlec 1979). In essence, wetlands are characterized by conditions that are considered undesirable in lakes and streams. Consequently, the quality of wetlands is generally described in terms of their use.

Wetlands are included in Michigan's WQS under the general category "other surface waterbodies within the confines of the state". The antidegradation rule contained in the standards provides some protection to wetlands. However, few of the criteria currently included in the standards are directly applicable to wetlands because of their unique environmental conditions relative to traditional measurements for good water quality.

4.3.7 Hazardous Waste

The generation, treatment, transport, storage and disposal of hazardous wastes are controlled by programs developed under the Hazardous Waste Management Act, 1979 PA 64. Waste disposal sites are also regulated under the federal Resource Conservation and Recovery Act (RCRA), 1976 PL 94-580. Clean ups and other responses to contaminated sites may occur under two programs, the U.S. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 1980 PL 96-510, commonly referred to as "Superfund", and the Michigan Environmental Response Act (MERA), 1982 PA 307. Both programs utilize risk assessments to evaluate the severity of contamination at specific sites based on known or potential impacts to (mainly) human health and the environment. Sites are then ranked according to their relative severity, thereby establishing priorities for remedial actions. The major difference between the programs is that Superfund sites are assessed based on conditions when the site was at its worst, and site assessments conducted under PA 307 are based on conditions at the time of assessment. Both of these programs may provide funding, on a priority basis, for remedial investigations, feasibility studies and clean up actions prior to identification of, and/or agreement on the course of action with a responsible party.

4.3.8 Pesticides

The use of pesticides is addressed through the Michigan Pesticide Control Act, 1976 PA 171. This act specifies requirements for registration of pesticide products, certification and licensing of pesticide applicators, and investigations of suspected pesticide problems. Public Act 171 adopts major portions of the Federal Insecticide, Fungicide and Rodenticide Act at the state level. This allows the state primacy in the areas of pesticide registration, labelling and distribution; licensure of pesticide dealers; certification of pesticide applicators; and, enforcement. In all other areas, the federal pesticide requirements apply. Pesticide programs are under the jurisdiction of the Michigan Department of Agriculture, which also manages programs for emergency response in cases where contaminants may enter food chains.

4.3.9 Air Quality

The Federal Clean Air Act, as amended in 1970 and 1977, directs the U.S. EPA to establish National Ambient Air Quality Standards. Since 1971, the U.S. EPA has established standards for seven pollutants: suspended particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone (photochemical oxidants), hydrocarbons and lead. Air pollution control is addressed through a permitting process similar to the NPDES process, under the authority of the federal Clean Air Act and the Michigan Air Pollution Act, 1965 PA 348.

The Clean Air Act Amendments were signed into law on November 15, 1990. The Act requires emission standards which reflect maximum achievable control technology to be developed for new and existing major sources of 190 air toxic compounds.

The Act also includes provisions specifically for the protection of the Great Lakes from toxic air pollutants. Michigan served as the lead state on efforts to address Great Lakes protection in the amendments. The Clean Air Act now requires EPA to promulgate emission standards for sources which account for 90 percent of the emissions of seven designated pollutants (Polycyclic organic matter, alkylated lead compounds, hexachlorobenzene, mercury, polychlorinated biphenyls, 2,3,7,8-tetrachlorodibenzofurans and 2,3,7,8-tetrachlorodibenzo-p-dioxin). The Act directs EPA to consider bioaccumulation and food chain effects of air toxins when performing the assessment of residual risks remaining after technology controls are applied. Additionally, the Act provides for a multi-year study of the extent and effect of atmospheric deposition into the Great Lakes and other waters. A Great Lakes monitoring network must be established by December 31, 1991 which must include a dry and wet deposition monitoring facility on the shores of each of the Great Lakes.

A 14 member Air Toxics Policy Committee was established in December of 1987 by the Michigan Air Pollution Control Commission and the MDNR to develop a long-range strategy for developing rules to regulate, control, and abate the emission of toxic air pollutants from both new and existing sources. The Committee decided to develop rules for new and modified sources first. Atmospheric deposition of toxic pollutants to the Great Lakes was a consideration in the rules development. The Committee presented the proposed regulations for new sources to the Commission in September 1989. Public hearings have been held and a summary of public comments and responses have been compiled. Discussions with industry and environmental representatives on further revisions to the draft rules are expected to lead to final agreement on the rules package by the fall of 1991 which will be submitted for the final stages of the legislative process.

Regional initiatives are also currently taking place to facilitate the reduction of toxic air pollutant emissions which can enter the Great Lakes Basin through atmospheric deposition.

The first initiative is the implementation of the Great Lakes States' Air Permitting Agreement. Signed by the Great Lakes Environmental Administrators in November 1988, the agreement commits the air regulatory programs to require the best available control technology for toxics on sources of compounds to the maximum degree allowed under existing authority. Special focus is placed on air emission sources of Great Lakes critical pollutants including mercury, alkylated lead compounds, total polychlorinated biphenyls, hexachlorobenzene, benzo-a-pyrene, 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin and 2, 3, 7, 8-tetrachlorodibenzofuran.

The second major regional initiative is the development of a regional air toxics emission inventory. In order to assure that adequate controls of toxic air pollutants will be required, the sources of toxic air pollutants must be identified. Emission inventories are the mechanism used to ascertain the type of pollutants and quantities emitted by an air pollutant source.

A grant was received from the regional Great Lakes Protection Fund to begin the process of developing a regional air toxics emission inventory. This fund was established by the eight Great Lakes states to fund research and demonstration projects that focus on the enhancement of Great Lakes ecosystem health. This comprehensive computerized database will identify 25 compounds of potential concern to the Great Lakes Basin emitted from area, point and mobile sources in eight states. If adequate funding is received, the initial computerized database will be completed in approximately 2 years, with capability to be updated on a regular basis.

Several air toxics monitoring initiatives are also taking place throughout the state of Michigan. The Michigan Urban Air Toxics Monitoring Program was established in January 1990. Sampling is being conducted to obtain information on 29 organic compounds and 13 trace metals surrounding three urban areas. The current sampling locations are in Kalamazoo, Midland and Detroit.

The MDNR Air Quality Division (AQD) initiated a "background" air monitoring project in November 1990. The program is funded, in part, by a grant awarded to the AQD from the Great Lakes Protection Fund. Air monitors are located at three rural areas in Michigan: Sault Ste. Marie, Traverse Bay and Saginaw Bay. Sampling is conducted monthly and will last one year for compounds considered by the International Joint Commission to be "critical pollutants" in the Great Lakes ecosystem. The compounds include: total polychlorinated biphenyls and 90 component congeners, polynuclear aromatic hydrocarbons, hexachlorobenzene, dieldrin and 13 trace metals of concern. The goal of this project is to confirm the presence and magnitude of these pollutants to develop baseline data for further research projects.

A second research proposal, would incorporate the data obtained from the "background study". AQD has requested funding from the Great Lakes Protection Fund to help support this project, the grants will be awarded summer 1991. MDNR AQD and the University of Michigan research staff would jointly conduct a study to investigate the transport, deposition and source areas of toxic contaminants measured across Michigan.

4.3.10 Fish Consumption Advisories

The Michigan Department of Public Health (MDPH) has issued fish consumption advisories since the early 1970s in an effort to provide guidance to the public on ways to reduce their exposure to contaminants from fish. The advisories are intended primarily for the frequent fish consumer because body burdens and risk of health problems from contaminants increase over time with repeated exposure. Because the impacts on reproduction and child development are largely unknown, pregnant women, nursing mothers, women who anticipate having children and children age 15 and under are especially advised not to consume contaminated fish.

The MDPH has adopted contaminant concentrations for edible portions of fish which, when exceeded, trigger consideration of a fish consumption advisory (Table 4.15). These "trigger levels" are based on U.S. Food and Drug Administration (FDA) regulatory guidelines, and the application of risk assessments.

Three different types of advisories may be issued depending on the percentage of specimens from a sample that exceed the trigger level(s). Advice on fish consumption for organic compounds is based on the following criteria:

a) No advisory for limiting consumption will be issued when contaminants are undetected or when 10 percent or less of the tests for a particular fish species and location exceed any of the advisory trigger levels as shown in Table 4.15.

Table 4.15 Trigger Levels Currently Used by MDPH in Establishment of Fish Consumption Advisories.

Chemical	MDPH Advisory Trigger
Chlordane	0.3 ppm
DDT	5.0 ppm
DDT metabolites (DDE, DDD)	5.0 ppm
Dieldrin (aldrin)	0.3 ppm
Dioxin (2,3,7,8 TCDD)	10.0 ppt*
Endrin	0.3 ppm
Heptachlor	0.3 ppm
Mercury	0.5 ppm*
Mirex	0.1 ppm
PCB	2.0 ppm
Toxaphene	5.0 ppm

* Different than FDA Regulatory or Advisory Guidelines; FDA uses 25 ppt for dioxin and 1.0 ppm for mercury; all others are currently the same.

b) An advisory for reduced consumption to no more than one meal per week will be issued when any of the advisory trigger levels are exceeded by more than 10 percent but less than 50 percent of the specimens tested for a particular species and location, and the mean concentrations do not exceed the trigger levels for the contaminants found. Nursing mothers, pregnant women, women who anticipate bearing children and children age 15 and under would be advised not to eat these fish. Michigan is likely to change this advisory to "Nursing mothers ..., and children under age 15 ..." in the 1991 advisory to promote consistency among the Great Lakes jurisdictions.

c) A "No Consumption" advisory will be issued when any advisory trigger level is exceeded by 50 percent or more of the specimens tested of a particular species and location.

Advice on fish consumption for mercury is based on a regression analysis of fish length versus mercury concentration. Consumption advisories due to mercury contamination would be issued for particular size categories as follows:

a) No advisory for limiting consumption will be issued when concentrations of mercury for a particular fish species and location are less than 0.5 ppm.

b) An advisory for reduced consumption to no more than one meal per week will be issued when mercury concentrations in a particular species from one location are between 0.5 and 1.5 ppm. Nursing mothers, pregnant women, women who intend to have children, and children age 15 and under should eat no more than one meal per month of the identified fish.

c) A "No Consumption" advisory will be issued when the mean mercury concentration in a particular species from one location exceeds 1.5 ppm.

When sufficient information to fully characterize the degree of contamination or human health risk does not exist, a precautionary position will be advocated until the situation can be fully evaluated.

The Health Advisory on fish consumption is published annually as part of the Michigan Fishing Guide. The advisory for the St. Clair River AOC is discussed in Chapter 6. The fishing guide is provided to each individual who purchases a fishing license, and is available free of charge from MDNR, MDPH and local health departments. Notices of consumption advisories are provided to the press and editors of sports journals.

4.3.11 Drinking Water Standards

The responsibility for drinking water regulations at the federal level is with the U.S. EPA. The federal Safe Drinking Water Act (SDWA) as amended in 1986 (PL 99-339, 100 State. 642) requires U.S. EPA to publish "maximum contaminant level goals" (MCLGs) for contaminants which in the judgement of the Administrator may have any adverse human health effects and which are known or anticipated to occur in public water systems. In addition to publishing MCLGs, which are non-enforceable health goals, the U.S. EPA must promulgate National Primary Drinking Water Regulations (NPDWR). The NPDWR may include either (a) a maximum contaminant level (MCL) or (b) a treatment technique. A treatment technique may be set only if it is not economically or technologically feasible to ascertain the level of a contaminant. An MCL must be set as close to the MCLG as feasible.

The 1986 amendments to the SDWA require the U.S. EPA to promulgate NPDWRs for 83 contaminants in three phases, by June 19, 1989. EPA has not met this schedule. In December of 1975, EPA published National Interim Primary Drinking Water Regulations for ten inorganic chemicals, six pesticides, and two microbiological indicator contaminants (total coliforms and turbidity). Some of these Interim Regulations, such as fluoride and coliform, have been finalized as NPDWRs. Other parameters such as Giardia and viruses, are being addressed by U.S. EPA through the establishment of required treatment techniques. The U.S. EPA is continuing to develop and promulgate NPDWRs for the remaining 83 contaminants.

National Primary Drinking Water Regulations under the SDWA are also to include monitoring requirements which assure a drinking water supply will dependably comply with the MCLs. The SDWA also contains public notification requirements should a public water supply (1) fail to comply with the MCL or treatment technique; (2) fail to comply with any monitoring requirements; (3) obtain a variance or exemption; or (4) fail to comply with any requirements of any schedule prescribed pursuant to a variance or exemption.

The federal SDWA delegates authority for the implementation of the Act to the states where the state has legislation which equals or exceeds the requirements of the Act. Any modifications to or deviations from the requirements must be approved by U.S. EPA.

The MDPH has had a drinking water program since 1913. The Michigan Safe Drinking Water Act, 1976 PA 399, was passed in 1976 with rules becoming effective in 1978. The Michigan SDWA authorizes the MDPH to provide for the supervision and control of public water supplies. The State regulations adopt the federal MCLs for organic and inorganic chemicals, microbiological contaminants, and turbidity contained in the federal act, except for radioactivity. There is no MCL for corrosivity, however monitoring requirements exist, and the water must be noncorrosive. The Michigan standards have been approved by the U.S. EPA as equivalent to or more stringent than the federal MCLs. A complete list of the MCLs and monitoring requirements for community water systems in Michigan is given in Appendix 4.5.

Drinking water standards apply after treatment either at the point of entry into the distribution system (plant tap), or at the point of use (the customer's tap) depending on the contaminant. The required sampling location for each contaminant is identified in Appendix 4.5. Drinking water standards do not apply to the raw water as taken from the waterbody (i.e. before treatment).

4.3.12 Michigan Waste Prevention Strategy

In February 1991, MDNR completed the development of a comprehensive strategy to reduce, at the source, waste generated by individuals, businesses and state government. The concept of waste prevention is relatively simple: If a waste is not created in the first place, it can never cause damage later. By avoiding the generation of waste at the source, waste prevention strategies are inherently the most protective of human health and the environment.

While it is true that progress has been made over the past several decades through expanded use of pollution controls and waste management practices, many persistent environmental problem remain. Environmental problems have become more difficult to predict and avoid when relying on pollution control alone. In short, such practices can no longer be relied on as the primary strategy to protect the environment, human health and, ultimately economic sustainability.

Michigan's Waste Prevention Strategy provides a vision in which future discharges to the air, water and land would be allowed only after a determination is made that there is no prudent and feasible alternative to its creation and discharge; and even then, only after sufficient treatment has been applied to meet the best available treatment technology requirements and other applicable standards. To realize this vision will mean a fundamental shift in permitting programs, which requires changes in statutes and rules.

A number of actions and recommendations to speed the implementation of waste prevention by individuals, businesses and state government are set forth in the strategy document. Recommendations include: enhanced education and promotion efforts for waste prevention; training programs; on-site technical assistance provisions to businesses; convening groups to discuss the feasibility of waste prevention initiatives in compliance and enforcement orders, environmental permits, cross-media inspections, banning certain toxic chemicals, etc.; and developing and implementing waste prevention plans for all state departments.

4.4 UNITED STATES - CANADA GREAT LAKES WATER QUALITY AGREEMENT

The Great Lakes Water Quality Agreement (GLWQA) was first signed by the governments of the United States and Canada in 1972 as a result of concern about degraded water quality in the Great Lakes. The Agreement confirmed both governments' commitment to enhance and restore Great Lakes water quality. The 1972 GLWQA provided the focus for a coordinated effort to control phosphorus inputs to the lakes, thereby addressing the eutrophication problem. In 1978, the GLWQA was revised and expanded in recognition of the need to understand the effects of toxic substances and control their discharge to the Great Lakes. The concept of an ecosystem approach to Great Lakes water quality management was also incorporated into the 1978 GLWQA. A protocol amending the GLWQA was signed by the two governments in 1987. The protocol adds specific programs, activities and timetables to address the issues identified in the 1978 Agreement.

The Agreement adopts General and Specific Objectives for the Great Lakes system, and sets forth the basic requirements for RAPs and Lakewide Management Plans (LaMPs). Annexes of the GLWQA address specific issues such as the control of phosphorus, discharges of polluting substances and wastes from vessels, dredging, surveillance and monitoring, point and nonpoint sources, etc. The GLWQA objectives, and the Annexes are described in the following sections.

4.4.1 General Objectives

The General Objectives of the GLWQA are found in Article III. General Objectives are broad descriptions of desired water quality conditions consistent with the protection of beneficial uses. These conditions include the absence of sludge deposits, floating materials, materials and heat producing color, odor, taste impairment or toxicity, and excessive nutrients. The General Objectives are intended to provide overall water management guidance to achieve a level of environmental quality to which both governments have agreed.

4.4.2 Specific Objectives

The specific objectives are described in Article IV of the GLWQA and listed in Annex 1. The objectives represent minimum levels of water quality and maximum concentrations of toxic substances in fish tissue agreed to by both federal governments. Under the agreement, the objectives may be amended, or new objectives added by mutual consent of both governments.

The 1987 amendments to the Agreement clarify that the Specific Objectives are consistent with the other portions of the Agreement (e.g. to virtually eliminate the discharge of any or all persistent toxic substances). Therefore, the Specific Objectives identified in Annex 1 for persistent toxic substances are adopted as Interim Objectives. A persistent toxic substance is defined as any toxic substance with a half-life in water of greater than eight weeks. A summary of the Specific Water Quality Objectives from Annex 1 is provided in Table 4.16. The reader is referred to the GLWQA for a complete listing.

Table 4.16 Great Lakes Water Quality Agreement Specific Objectives for Ambient Water Quality. (All concentrations are in $\mu g/L$ unless otherwise noted.)

Parameter	Specific Objectives ($\mu g/L$)
INORGANICS[a]	
Arsenic	50.0
Cadmium	0.2
Chromium	50.0
Copper	5.0
Iron	300.0
Lead	b
Mercury	0.2
Nickel	25.0
Selenium	10
Zinc	30.0
Fluoride	1200.0
Total Dissolved Solids (mg/L)	200[c]
Ammonia, unionized	20.0
total	500.0
ORGANICS	
Aldrin + Dieldrin	0.001
Chlordane	0.06
DDT + metabolites	0.003
Endrin	0.002
Heptachlor + Heptachlor Epoxide	0.001
Lindane	0.01
Methoxychlor	0.04
Mirex	d
Toxaphene	0.008
Dibutyl phthalate	4.0
Di(2-ethylhexyl)phthalate	0.6
Other phthalic acid esters	0.2
Phenol	1.0
Diazinon	0.08
Guthion	0.005
Parathion	0.008
Unspecified, persistent organic compound	d

a All metals (except mercury) are the total of all forms present in an unfiltered sample. Total mercury shall be measured in a filtered sample.

b Value for Lake Superior - 10 $\mu g/L$; Lake Huron - 20 $\mu g/L$; remaining Great Lakes - 25 $\mu g/L$.

c Present (as of 1978) levels should be maintained, but 200 mg/L must not be exceeded.

d Should be less than detection levels as determined by the best scientific methodology available.

Specific objectives for contaminant concentrations in fish for the protection of human health, and fish eating birds are shown in Table 4.17.

Table 4.17 GLWQA Specific Objectives for Fish Tissue. (Concentrations are given in $\mu g/g$ on a wet weight basis.)

Parameter	Concentration in Edible Portion[a]	Whole Fish[b]
Mercury	---	0.5
PCB	---	0.1
Aldrin + Dieldrin	0.3	---
DDT + metabolites	---	1.0
Endrin	0.3	---
Heptachlor + Heptachlor epoxide	0.3	---
Lindane	0.3	---
Mirex	---	c

a Great Lakes Water Quality Agreement objectives for protection of human consumers of fish.
b GLWQA specific objectives for protection of birds and animals which consume fish.
c Concentrations should be less than detection as determined by the best scientific methodology available.
Note: "---" indicates that the GLWQA does not contain specific objectives.

4.4.3 GLWQA Annexes

There are 17 annexes to the GLWQA. They are an integral part of the Agreement and set forth objectives, principles, programs, and reporting requirements to which both federal governments have agreed. As such, the annexes must also be considered in the development of the RAP.

Annex 1, previously described, lists the Specific Objectives and requires the compilation of three lists of substances which are present or potentially present within the water, sediment or aquatic biota of the Great Lakes System and believed to have acute or chronic toxic effects on aquatic, animal or human life. The first list identifies known toxicants present in the aquatic ecosystem. The second list identifies compounds which are present and suspected of causing toxic effects on aquatic, animal or human life. The third list is used to identify known toxicants which may be present in the aquatic ecosystem. To date, the Parties have made little progress toward compilation of these lists.

Annex 2 discusses the Remedial Action Plans (RAPs) and Lakewide Management Plans (LaMPs), including the designation of Areas of Concern (AOCs), and the contents and reporting requirements for RAPs and LaMPs. While most of the jurisdictions have actively worked toward development of RAPs for the AOCs, the Parties have made little progress in development of LaMPs for the Great Lakes.

Annex 3 includes programs for the control of point and non-point sources of phosphorus into the Great Lakes System. For example, in 1976, the estimated total phosphorus load to Lake Erie was 20,000 metric tons per year. The estimated load that will be discharged when all municipal waste treatment facilities over 1 MGD achieve compliance with the 1 mg/L effluent concentration (as required by Article VI of the GLWQA) will be 13,000 metric tons per year to Lake Erie. The phosphorus target load (point and non-point sources combined) for Lake Erie is 11,000 metric tons/year to meet ecosystem objectives.

Annexes 4, 5, 6, 8, and 9 address the discharge of oil and hazardous polluting substances and wastes from vessels and onshore and offshore facilities. These annexes set forth criteria to be adopted by both countries for (1) the prevention of discharges of oil and hazardous polluting substances; (2) the prohibition of discharge of garbage; (3) the prohibition of discharge of wastewater (including ballast water) in harmful amounts or concentrations; and (4) the requirement for vessels to contain, incinerate, or treat sewage to an adequate degree.

Efforts to prevent introductions of zebra mussels by way of ballast water were undertaken by the U.S. and Canadian Coast Guards, acting under the GLWQA. The Canadian Coast Guard in consultation with the U.S. Coast Guard, St. Lawrence Seaway Authority, Shipping Association, Fisheries and Oceans Canada, Environment Canada and the Great Lakes Fisheries Commission, established voluntary guidelines that became effective May 1, 1989. These guidelines specify that ships entering the Seaway should exchange their ballast off the continental shelf at depths greater than 2000 meters. In the event that this is not possible, ballast water may be exchanged in the Laurentian Channel in the Gulf of St. Lawrence.

The Canadian Coast Guard and U.S. Coast Guard are responsible for the review of services, systems, programs, recommendations, standards and regulations relating to shipping activities for the purpose of maintaining or improving Great Lakes water quality. Annex 9 provides for the continued maintenance of the joint contingency plan (CANUSLAK) developed under Annex One of the Canada - United States Joint Marine Contingency Plan. The purpose of the plan is to provide for a coordinated and integrated response to pollution incidents in the Great Lakes System.

Annex 7 establishes a subcommittee under the IJC Water Quality Board to review dredging practices and to develop guidelines and criteria for dredging activities in the boundary waters of the Great Lakes Systems. The subcommittee is also responsible for development of specific criteria to classify contaminated sediments of designated areas of intensive and continuing dredging activities in the Great Lakes System.

Annex 10 directs the Parties to establish and maintain two lists of substances known to have, or potentially have, toxic effects on aquatic or animal life of which there is a risk of being discharged into the Great Lakes System. These lists are included as Appendices 1 and 2 of the Annex. The two governments are directed to develop and implement programs to minimize or eliminate the risk of release of these substances into the Great Lakes System.

Surveillance and monitoring activities are outlined in Annex 11. In general, the purpose of these activities is: (1) to ensure that jurisdictional control requirements are being met, (2) to gather data to measure the progress toward achieving the General and Specific Objectives, (3) to evaluate water quality trends, and (4) to identify emerging water quality problems. This annex supports the development of RAPs and LaMPs pursuant to Annex 2.

Annex 12 defines persistent toxic substances and sets forth regulatory strategies and programs to be adopted by both countries for controlling or preventing the input of such substances into the Great Lakes Systems. Monitoring and research programs, including the establishment of an early warning system to anticipate future toxic substances problems and the establishment of action levels to protect human health, are addressed in this annex. The general principles to be followed in the development and adoption of regulatory strategies and programs under this Annex include the virtual elimination of the input of persistent toxic substances, and the reduction in generation of contaminants.

Annex 13 further delineates programs and measures for the abatement and reduction of nonpoint sources of pollution from land-use activities. These measures include efforts necessary to further reduce nonpoint source inputs of phosphorus, sediments, toxic substances and microbiological contaminants contained in drainage from urban and rural land, including waste disposal sites, in the Great Lakes Systems. The annex refers to RAPs and LaMPs as information sources to identify nonpoint source concerns, and to assist in the development and implementation of watershed management plans. The annex also calls for the identification and preservation of wetland areas and the determination of nonpoint source pollutant loadings to the Great Lakes System.

Annex 14 is an agreement between the two countries to study the issue of contaminated sediments, determine the impact of contaminated sediment on the Great Lakes Basin Ecosystem, and develop a standard approach and agreed procedures for the management of contaminated sediment. The annex requires the governments of both countries to evaluate existing technologies for the management of contaminated sediment and to implement demonstration projects at selected AOCs. Information obtained through this research should be used to guide the development of RAPs and LaMPs.

Atmospheric deposition of toxic substances to the Great Lakes Ecosystem is addressed in Annex 15. The annex requires that the Parties conduct research to determine pathways, fate and effects of airborne toxic substances in the Great Lakes Systems. An Integrated Atmospheric Deposition Network is to be established to (1) identify and track airborne toxic substances; (2) determine atmospheric loadings of toxic substances to the Great Lakes System; and (3) define temporal and spacial trends in the atmospheric deposition of toxic substances. Pollution control measures will be developed and implemented for sources found to have significant adverse impacts on the Great Lakes System.

Annex 16 directs the governments of both countries to identify and assess the impact of contaminated groundwater on the Great Lakes System. This information should be used in the development of RAPs and LaMPs. The governments agree to control the sources and the contaminated groundwater itself.

Annex 17 describes research necessary to achieve the goals of the GLWQA. This includes research of the sources and fate of toxic substances in the Great Lakes System, and their ecotoxicity. Also addressed are research needs on the effects of varying the lake levels, and the impact of water quality and the introduction of non-native species on fish and wildlife populations and habitats. The need for the development of control technologies for point source discharges, for action levels for contamination which incorporate multimedia exposure, and for epidemiological studies to determine the long-term, low-level effects of toxic substances on human health are also discussed in this annex.

4.5 ONTARIO-MICHIGAN EMERGENCY NOTIFICATION PROTOCOL

The Province of Ontario and the State of Michigan have agreed to notify each other and provide appropriate information in the event of an accidental discharge to the water or air in areas that may have transborder impacts. Detailed emergency notification procedures outlining contact responsibilities and orders have been established for spills originating in both Ontario and Michigan. Notification flow diagrams are provided in Figures 4.1 and 4.2, respectively

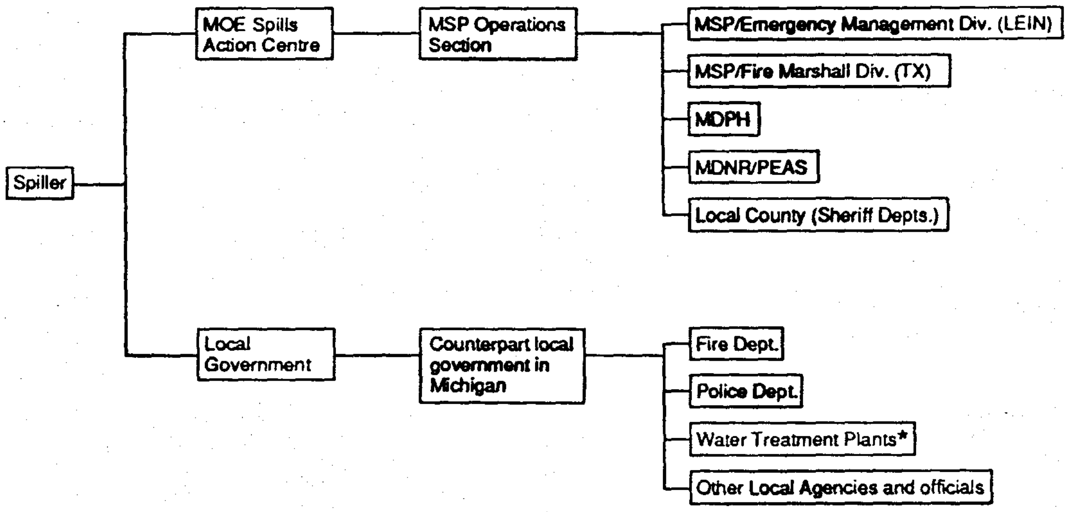
In the event of a spill in the transborder area of Ontario the spiller will contact the local government in Ontario and the OMOE-Spills Action Center. The local government contacts their Michigan counterpart while the OMOE Spills Action Center will contact the Michigan State Police (MSP) Operations Section. The local governments in Michigan will contact the Fire Department, Police Department, water treatment plants and other local agencies. The MSP Operations Section will contact MSP/Emergency Management Division, MSP/Fire Marshall Division, Michigan Department of Public Health, MDNR/Pollution Emergency Alert System and the local county sheriff departments.

In the event of a spill in the transborder area of Michigan the spiller will contact the local government who will contact the MSP/Operation Section and their Ontario counterpart. The MSP Operations Section will contact the MSP/Emergency Management Division, MSP/Fire Marshall Division, Michigan Department of Public Health, MDNR/Pollution Emergency Alert System and OMOE Spills Action Center.

Figure 4.1

St. Clair River Remedial Action Plan

Notification flow diagram for spills originating in Ontario

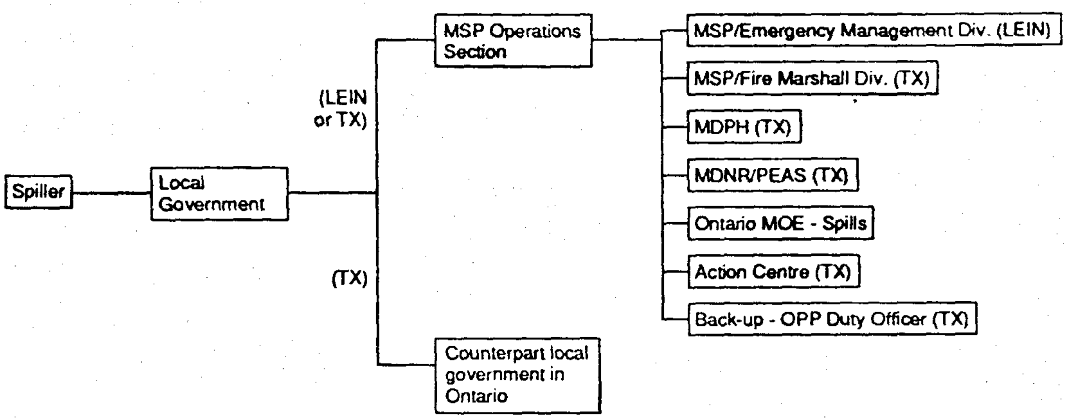


* notified of all events

Figure 4.2

St. Clair River Remedial Action Plan

Notification flow diagram for spills originating in Michigan



5.0 DESCRIPTION OF THE STUDY AREA

5.0 DESCRIPTION OF THE STUDY AREA

5.1 LOCATION AND EXTENT

The boundaries of the St. Clair River AOC include the entire river from the Bluewater Bridge (connecting Port Huron and Sarnia) to the southern tip of Seaway Island, west to St. John's Marsh and east to include the north shore of Mitchells Bay on Lake St. Clair (Figure 5.1). Anchor Bay of Lake St. Clair is not included.

The St. Clair River, together with Lake St. Clair and the Detroit River, form a complex connecting channel between Lake Huron and Lake Erie. The St. Clair River, which begins at the southern end of Lake Huron, flows approximately 64 km (40 mi) in a southerly direction to Lake St. Clair, where it divides into several channels, creating an extensive delta known as the St. Clair Flats (Figure 5.1). The river also forms the international boundary between Canada and the United States. Both sides of the river have highly urbanized portions. The City of Sarnia and the towns of Corunna, Mooretown, Courtwright, Sombra and Port Lambton border the Ontario shore, while the cities of Port Huron, Marysville, St. Clair, Marine City and Algonac are along the Michigan shore.

There are two islands located in the main channel: Stag Island, adjacent to the Town of Corunna, and Fawn Island, adjacent to Marine City. Several islands have been created by the division of the river into numerous channels in the St. Clair Flats. On the Canadian side, Walpole Island and consists of six separate islands, all of which are separated by a series of channels. Seaway Island lies between the South Channel and the St. Clair Cutoff, and Bassett Island is between the St. Clair Cutoff and Bassett Channel. The largest island complex consists of three separate land masses (Squirrel Island, Walpole Island, and Pottowatamie Island). St. Anne Island on the east is sandwiched between Johnston Channel and Chenal Ecarte. Collectively, the islands on the Canadian side form the Walpole Island Indian Reserve. On the American side, Dickinson Island is located between the North Channel and the Middle Channel and Harsens Island lies between the Middle and South Channel. The three principal channels, the North Channel (including the Middle Channel), the South Channel (including the St. Clair Cutoff), and Chenal Ecarte carry 53 percent, 42 percent and 5 percent, respectively of the river's flow to Lake St. Clair (Edsall et al. 1988a). The total shoreline length of the St. Clair River, including these three main channels, is 192 km (119 mi).

A number of tributaries flow into the St. Clair River. In Canada, the principal tributary is Talfourd Creek which has an area of 20,800 ha (51,400 acres). Smaller tributaries (Figure 5.1) include Baby, Bowens, Clay, Marshy and Murphy Creek. The combined watersheds of all tributaries to the river, except Marshy Creek, total only 20,976 ha (51,810 acres); all within Lambton County. The Sydenham River is the largest river on the Canadian side, however, it flows into the Chanel Ecarte which then discharges to Lake St. Clair. In the United States, the principal tributaries are the Black River, the Pine River and the Belle River which collectively drain a total watershed of 315,900 ha (780,600 acres) from the counties of Lapeer, Macomb, Sanilac and St. Clair. Smaller tributaries which drain into the St. Clair River from the American side include Bunce Creek and Marine City Drain.

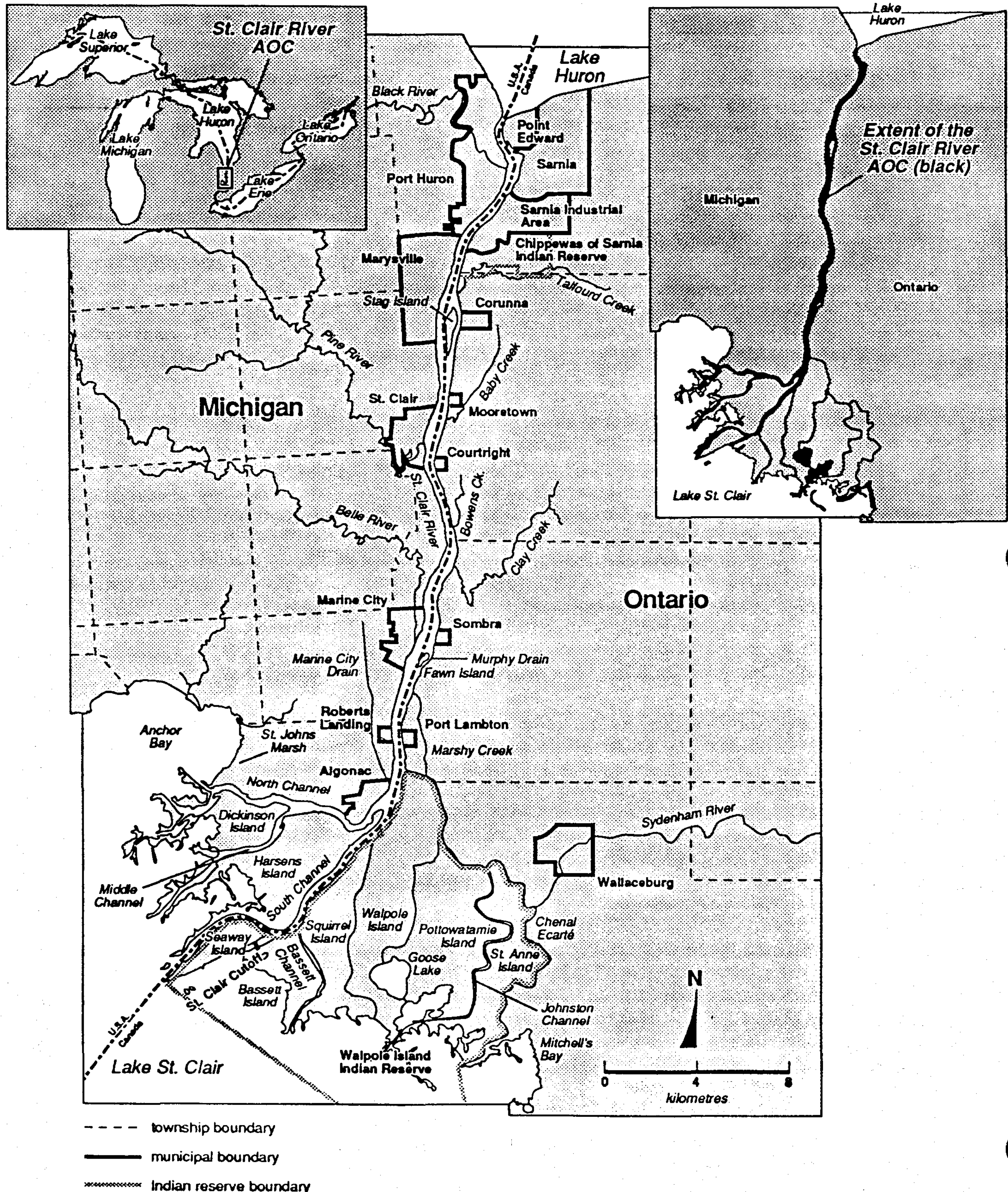
The St. Clair River is the natural outlet of Lake Huron draining into Lake St. Clair where it has formed the only major riverine delta in the Great Lakes – the St. Clair delta, also known as the St. Clair Flats. The conditions which have contributed to its formation are: rapid deceleration of the river's flow as it disperses into the wide, shallow Lake St. Clair; very high suspended sediment loads carried from Lake Huron; stable conditions at the river/lake interface since the channel was first established; and the river's straight channels with few islands or other depositional sites (UGLCCS 1988, p.20).

Figure 5.1

St. Clair River Remedial Action Plan

Location map of the St. Clair River area of concern (AOC)

(after UGLCCS 1988)



5.2 CLIMATE

The area surrounding the St. Clair River typically has mild summers and cold winters. Average monthly air temperatures at Port Huron, Michigan reach a low of -4.4 C (24.1°F) in January and a high of approximately 21.5°C (70.7°F) in July (Figure 5.2); a similar regime occurs at Windsor, Ontario. The temperature of the area is greatly influenced by Lake Huron. Its warm waters act as a heat sink in the fall, delaying frost and extending the growing season into October (Eichenlaub, 1979). In the spring, the cold lake temperature slows the rise of air temperature; this prevents premature vegetational growth and lessens the chances of crop and plant losses owing to late spring frosts (Eichenlaub, 1979). The frost-free season,defined as the period between the last day of spring and the first frost of autumn, is 160 days (Edsall et al. 1988a); which provides the region with one of the longest growing seasons in the Great Lakes Basin.

Average monthly water temperatures at Port Huron from 1974 through 1984 ranged from a low of 0.5°C (32.9°F) in January, February and March to a high of 21.7°C (71.1°F) in August. The mean water temperature for the years of 1967 to 1982 for the St. Clair River was 11.8°C (53.2°F) (UGLCCS 1988, p.231).

Mean monthly precipitation ranges from a low of 3.6 cm (1.4 in) in February to a high of approximately 8.2 cm (3.2 in) in June at Port Huron (Figure 5.2). During the winter months, precipitation is mainly in the form of snow. Precipitation in the area is related to cyclonic storms and convectional uplift (Edsall et al. 1988a). Cyclonic storms, which can occur throughout the year, are most commonly seen during the fall and winter months; they can produce seiches, with a resulting elevation in water levels and flooding of low-lying shoreline. Convectional uplifts produce frequent summer thunderstorms in the region.

Ice jams have occurred occasionally along the river, impeding shipping, and affecting water levels in both Lake Huron and Lake St. Clair (Edsall et al. 1988a).

5.3 ST. CLAIR RIVER HYDROLOGY, HYDRAULICS AND MORPHOLOGY

5.3.1 Hydrology and Hydraulics

Flow velocities range from 1.67 m/s (5.48 ft/s) at the Blue Water Bridge to 0.31 m/s (1.02 ft/s) at Lake St. Clair. The average flow rate is 0.97 m/s (3.18 ft/s) (Edsall et al. 1988a). Water velocities and flow times are illustrated in Figure 5.3. Variations in flow velocities along the length of the river are a result of changing depths, widths and gradient. The total average fall from Lake Huron to Lake St. Clair is 1.5 m (4.9 ft) (Edsall et al. 1988a). The mean flow time from Lake Huron to Lake St. Clair is 21.1 hours.

Three distinct reaches can be identified based on hydraulic characteristics and water velocities. The physical and hydraulic characteristics of each reach are shown in Table 5.1.

(1) A narrow upper reach extending from Lake Huron to the mouth of the Black River. The change in elevation within this reach is only 0.3 m (0.98 ft).

(2) A wider middle reach extending 39 km from the Black River to the apex of the St. Clair Delta near Algonac in which the channel falls only 1.1 m (3.6 ft). The middle reach is generally a uniform, rectangular channel. The widest portions of the channel occur at Stag and Fawn Islands and the St. Clair Middle Ground Shoal located opposite St. Clair, Michigan, where the channel widens to 1,200 m.

Figure 5.2

St. Clair River Remedial Action Plan

Average monthly air temperatures and precipitation at Port Huron, Michigan and Windsor, Ontario

(Edsall et al. 1988a)

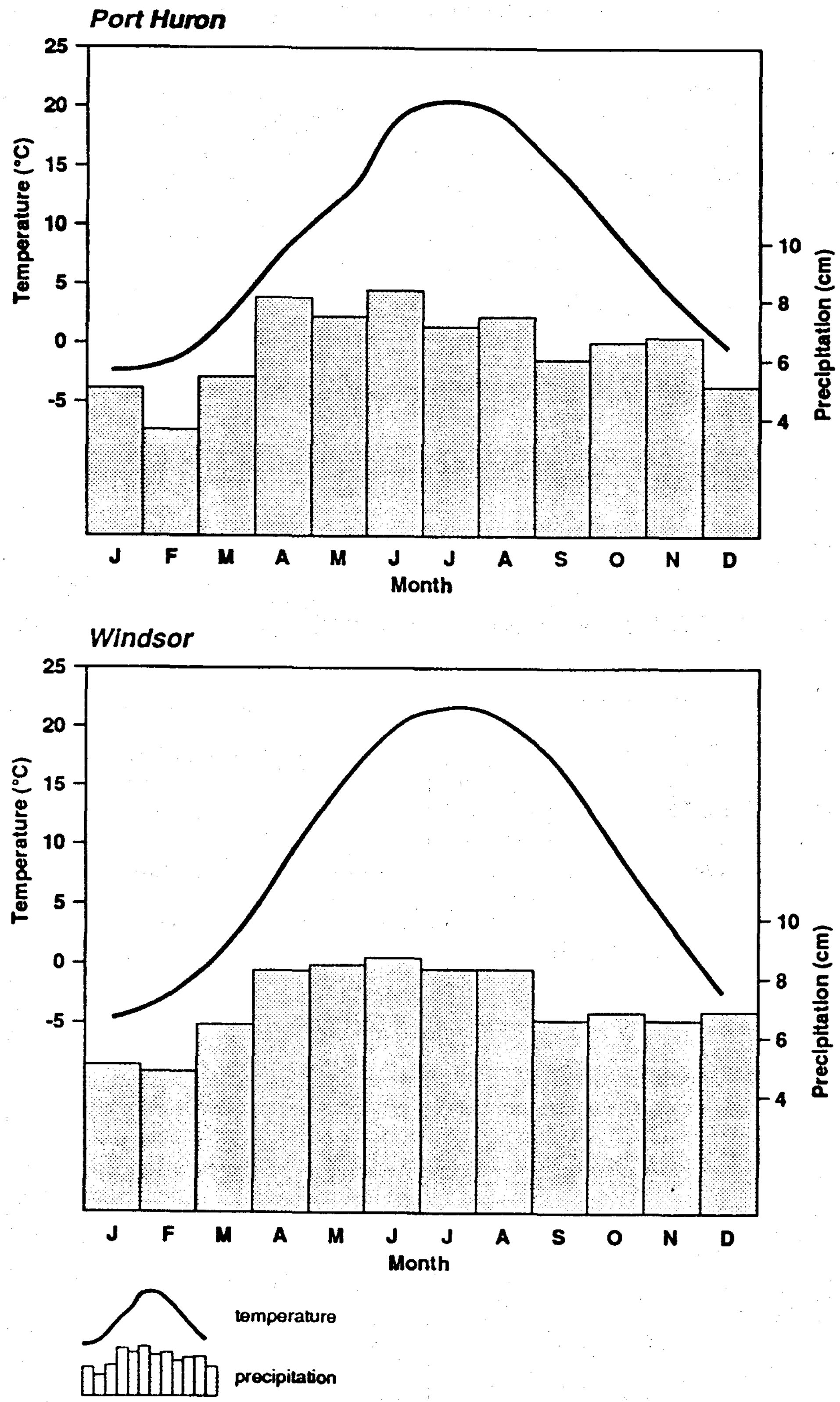
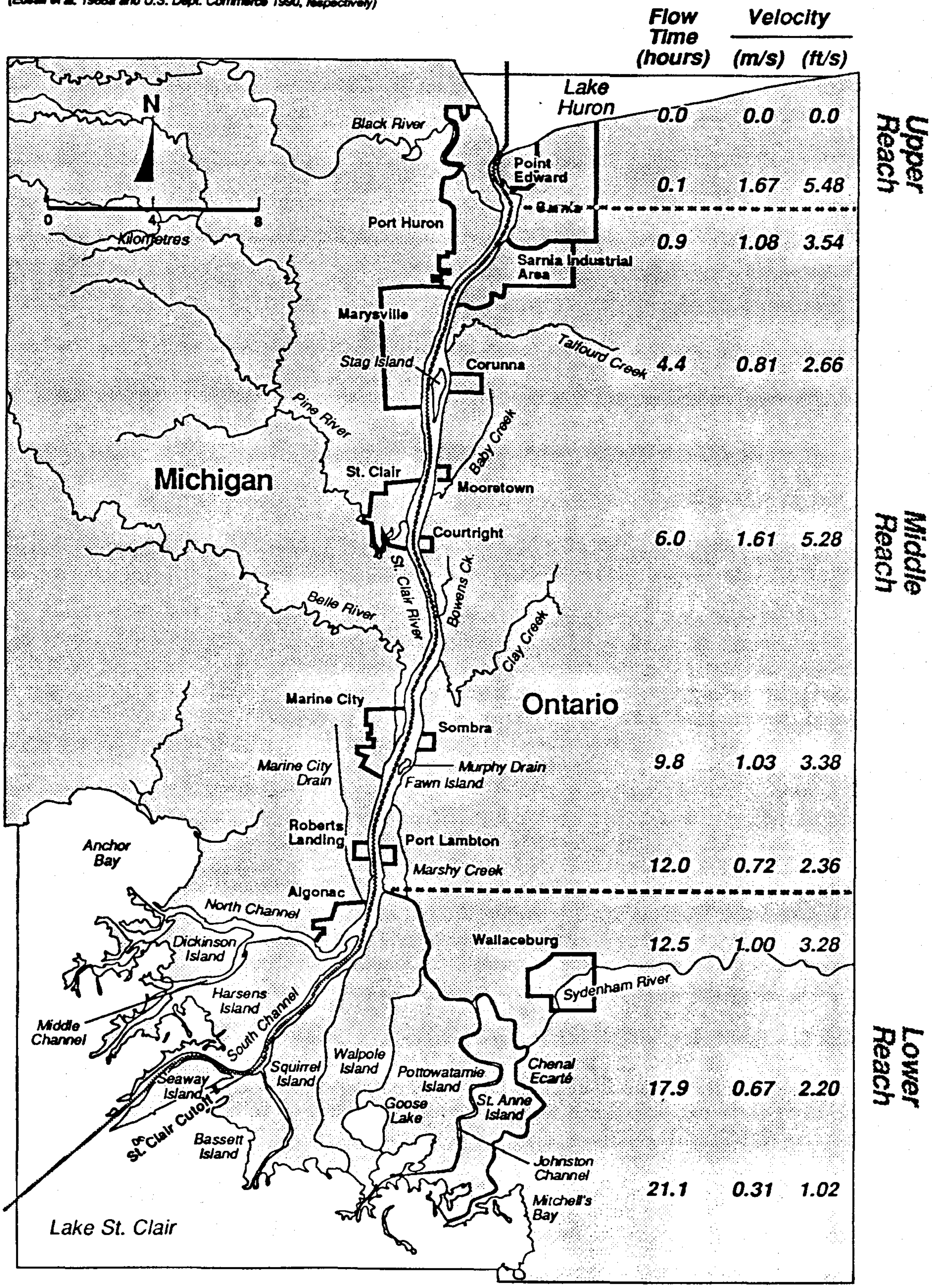


Figure 5.3

St. Clair River Remedial Action Plan

Average flow times and water velocities of the St. Clair River and the location of the Great Lakes / St. Lawrence Seaway Navigation Channel

(Edsall et al. 1988a and U.S. Dept. Commerce 1990, respectively)



navigation channel

Table 5.1 Physical and Hydraulic Characteristics of the St. Clair River (Limno-Tech, 1985).

Site	Winter Ice Conditions	Length (km)†	Depth (m)	Elevation (m)	Width (m)	Avg Flow (m^3/s)	Monthly Low Flow (m^3/s)	Monthly High Flow (m^3/s)	Avg Flow Velocities (m/sec)
St. Clair River	Channel clear	64	9-21	1.5	250-1200	5100	4200	5500	0.6-1.8
Upper	Channel clear	1	9-21	0.3	250-450				1.67*
Middle	Channel clear	39	8-15	1.1	600-1200				1.05*
Delta	Ice jams	25	3-27	< 0.2					0.66*

* Flow velocities calculated from Edsall et al. 1988.
† Lengths from UGLCCS 1988.

(3) A lower reach in the delta region which extends 25 km downstream to Lake St. Clair. The river is divided into several distributary channels with gentle slopes. The channels in the delta are, on average, the slowest and have the lowest gradients of the three reaches. Depths within the delta are highly variable ranging from 27 m (88.6 ft) in the North Channel, south of Algonac, to less than 3 m (9.84 ft) over river-mouth bars in distributary channels.

The average volume of water carried by the river varies seasonally from a winter low of 4,200 m^3/s (148,210 cfs) to a summer high of 5,500 m^3/s (194,084 cfs) (Limno-Tech 1985). The average monthly discharge rate, from 1900 to 1981, was 5,121 m^3/s (180,710 cfs) (Edsall et al. 1988a). River water is almost entirely from Lake Huron, with contributions from tributaries along the St. Clair River being small.

According to Edsall et al. (1988a), short term storm surges will cause Lake Huron water levels to rise and velocities to exceed the norm by 1.5 times. Lower flow velocities in the Algonac area result in the formation of ice jams, thus decreasing the river flow and creating upstream flooding problems and the temporary dewatering of wetlands surrounding Lake St. Clair. Interlake shipping is affected from February to April. A record ice jam occurred in the St. Clair River in 1984. Ice jams, greater than 3 m (10 ft) thick occurred at the apex of the delta leading to a decrease in discharge from the monthly average of 5,096 m^3/s 179,828 cfs) to about 2,520 m^3/s (88,925 cfs) for April (Edsall et al. 1988a).

Channel dredging in the St. Clair River since 1900 has altered river levels and discharge to Lake St. Clair (Edsall et al. 1988a). Between 1908 and 1925 gravel at Point Edward was removed for commercial uses. Uncompenstated (i.e., without water level control structures) navigational channels 7.6 m (24.9 ft) and 8.2 m (26.9 ft) in depth were completed in 1933 and 1962, respectively. These channel changes increased the discharge of Lakes Michigan and Huron (hydraulically one lake) through the St. Clair River and permanently lowered their levels by 0.27 m (0.89 ft), representing a 32 km^3 (7.68 mi^3) water loss (Derecki 1985). The construction of the St. Clair Cutoff Channel in 1962 decreased the flow in the North Channel, hence, decreasing the proportion of St. Clair River water entering Lake St. Clair through Anchor Bay.

Present flow distribution within the distributary channels of the delta are shown in Figure 5.4. The discharge of the St. Clair River north of Chenal Ecarte is 5,121 m^3/s (180,710 cfs). Only 8 percent (410 m^3/s or 14,468 cfs) of this flow passes through the Ontario distributaries excluding the St. Clair Cutoff Channel. Most (92%) of the discharge passes through the Michigan sector of the delta suggesting active delta growth in this area (Edsall et al. 1988a).

The St. Clair River "behaves like three separate panels of water: two nearshore sections strongly influenced by discharges; and a centre panel which passes through the river with minimal change" (UGLCCS 1988,

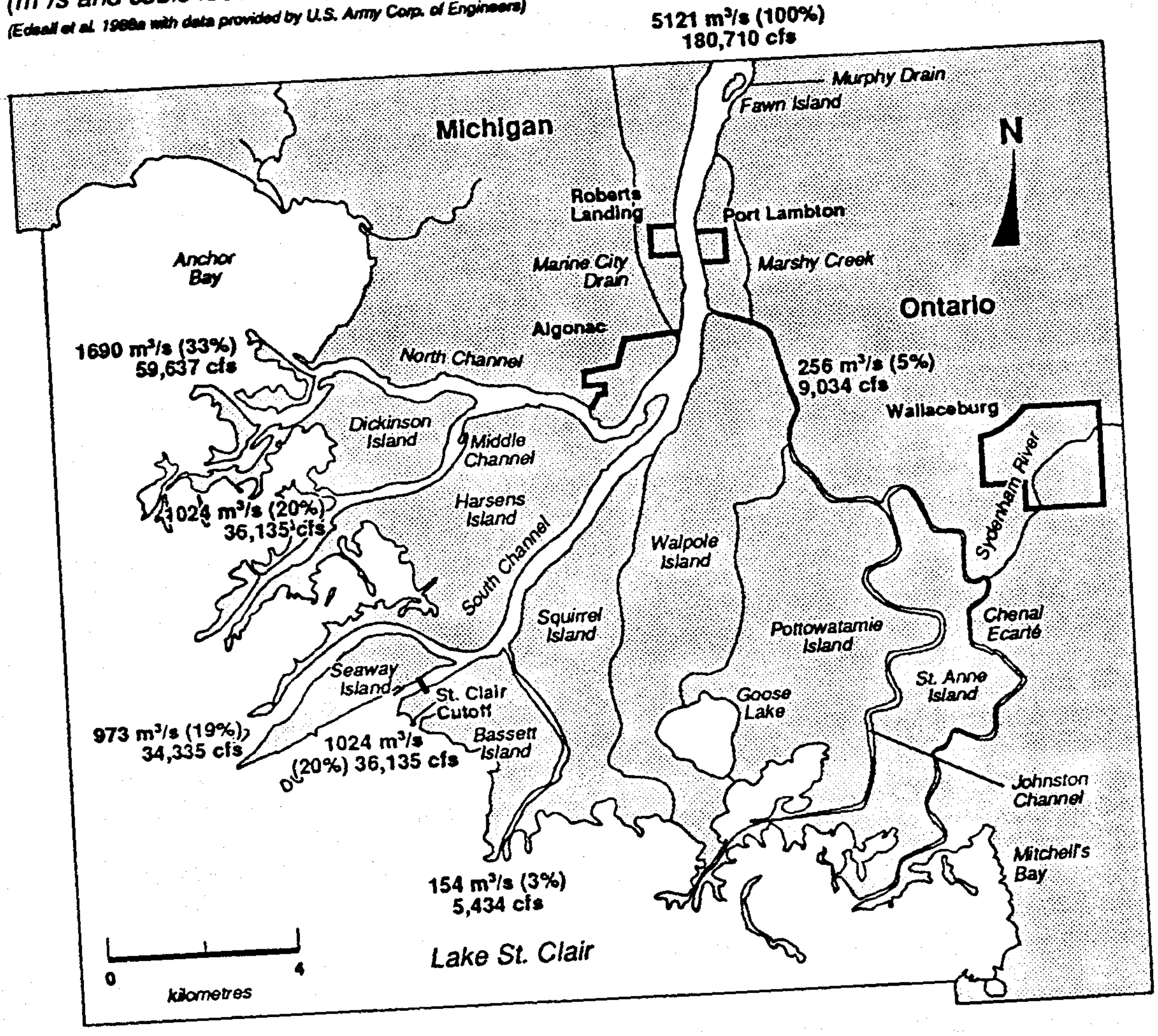
Figure 5.4

St. Clair River Remedial Action Plan

Average flow distribution in the St. Clair Delta

(m^3/s and cubic ft/sec with percent total flow shown in parentheses)

(Edsall et al. 1988a with data provided by U.S. Army Corp. of Engineers)



pg 224). Based on the high flow of the river, one would expect that chemicals from sources along the river would be readily diluted. However, because of the flow pattern of the river, contaminant plumes tend to hug the shoreline resulting in approximately 5 percent of the total flow available for dilution (UGLCCS 1988).

Water sample transects across the upper and lower reaches of the St. Clair River were analyzed for hexachlorobutadiene (HCBD), pentachlorobenzene (QCB), hexachlorobenzene (HCB) and octachlorostyrene (OCS). Results showed that a plume of contaminants discharged to the river by the chemical industry at Sarnia spreads slowly downstream and is confined to within 300 m of the Canadian shoreline at Port Lambton, 34 km downstream (Chan et al. 1986). Sediment samples similarly showed the same contaminant distribution with no transboundary movement in the river (Oliver and Pugsley 1986).

5.3.2 River Morphology

The St. Clair River is morphologically unusual in the fact that it is a strait and it does not have a large network of tributaries. Most river deltas are comprised of fine sediment, however, nine boreholes between the town of St. Clair southward to the apex of the delta reveal that sand and gravel are the primary sediments transported by the river (Edsall et al. 1988a). The river flows through glacial tills and lake plain clays. Although the St. Clair River has created a channel in very fine sediments, the bulk of material transported is coarser.

Limited depth and morphological data are available on hydrographic charts. Rukavina (1986) mapped the channel morphology and sediment cover in the reach of the St. Clair River along Sarnia's industrial shoreline. He found that the channel shape and depth varied along the river. At the north end of the river the channel has steep, smooth sides and a central ridge separating Canadian and U.S. sub-channels 4 to 2 m (13.1 to 6.6 ft) deep, respectively. Further south, the slope of the U.S. shore decreases and the sub-channels become less prominent resulting in a shallower single channel skewed towards the Canadian shore.

The St. Clair Delta is the river's most significant landform. The delta has the classical bird-foot morphology and characteristics of marine deltas with the main difference being unusually wide distributary channels. The delta, also known as the St. Clair Flats, consists of two morphologically different units: the pro-delta, which is a large submarine base of silt and fine sands and the sub-aerial delta, which includes further deposits which extend up to or above the surface of the river (Edsall et al. 1988a). In reality, there are two modern flats. The first was formed on the Ontario side of the river and the Chenatoga, Chenal Ecarte and Johnson Channels were their principal outlets. These streams were subsequently replaced by the North, Middle and South Channels as principal outlets. Today, the flats continue to develop in this area with very little deposition occurs on the eastern side (Edsall et al. 1988a).

5.4 RIVER SEDIMENTS

5.4.1 Sediment Type and Composition

Literature on the physical and chemical characteristics of the sediment of the St. Clair River, up to and including 1987, was summarized by the Sediment Workgroup (1987) of the Upper Great Lakes Connecting Channels Study (UGLCCS). Information on the physical characteristics of St. Clair River sediments utilized by the UGLCCS Sediment Workgroup (1987) are derived primarily from Rukavina (1986), Great Lakes Institute (1986), and Bertram et al. (1987).

The bed of the St. Clair River is cut into hard, stony clay till (the Black Shale Till). This stony till is overlain by a silty clay till (the St. Joseph Till) which forms the upper banks of the river (Rukavina 1986). The eroded till surface, along with boulders and gravel which have been eroded from the till, cover most of the bottom. Observations by divers and underwater cameras have shown the bottom to consist of a pavement of well-rounded cobbles and boulders with sand in the interstices over cohesive clay till. In places, sand ripples and dunes form on the bed of the river from sand which is carried as bed load (i.e., material which is rolled along the bottom of the river being too coarse to be suspended in the river).

Very little information is available on the geochemistry of St. Clair River sediments. The UGLCCS Sediment Workgroup (1987) noted that the data available indicate that the sediment geochemstry closely resembles that of the Detroit River.

5.4.2 Sediment Thickness

Core samples collected at 2 km (1.25 mi) intervals near the Ontario shore along the entire river south of Sarnia reveals a surficial sand and gravel cover of variable thickness overlying cohesive clay till (Sediment Workgroup 1987). Sediment thickness along the Ontario shoreline from Sarnia to Chenal Ecarte varies from 0 cm to more than 32 cm (12.5 in) with the thickest deposits occurring nearest the shore (Table 5.2, Figure 5.5). Thus, in cross-section the sediments are wedge-shaped, tapering to a thin edge approximately 100 m (328 ft) offshore. No relationship was observed between the thickness of the deposits and distance downstream. The average thickness of the deposit was estimated at by Rukavina (1986) to be 10 cm (3.9 in).

5.4.3 Sediment Particle Size

Sediments within the St. Clair River can be grouped into two basic types according to grain size: 1) fine grained cohesive glacial clays (till) which form the eroded bed of the river; and 2) a veneer of river sediments which is coarse and granular. The first type occurs primarily in the main channel of the river where the current prevents deposition of sediment. The second type occurs as a veneer over the till away from the main channel. Clay is the major component of the glacial till, with sand making up less than 10 percent and gravels being negligible; the mean particle size for this type of sediment is less than 0.008 mm (0.0003 in) (Rukavina 1986).

The second sediment type shows large variations in grain size, but no consistent pattern in size along the course of the river. The average texture is 63 percent sand, 32 percent gravel and 5 percent silt and clay (Rukavina 1986). Mean particle size ranges from 0.1 mm to 9.0 mm (0.0039 to 0.35 in), averaging 1.7 mm (0.066 in); however, two size classes predominated: fine gravels, ranging from 4 mm to 32 mm (0.156 to 1.25 in) in diameter and fine to medium sand of 0.1 mm to 0.5 mm (0.0039 to 0.20 in) diameter. Other studies of particle size in the surficial sediments overlying the clay till show a wide range of particle size. The UGLCCS Sediment Workgroup (1987) concluded that, on average, the unconsolidated sediment (i.e., nontill) could be classified as fine to medium sand.

5.4.4 Sediment Origin and Transport

The sediment load carried by the river is almost completely derived by erosion and transport from the shoreline and shallow nearshore area of southern Lake Huron (Sly and Lewis 1972). Rukavina (1986) notes, however, that the sand and gravel which overlie the clay till of the river bed may also be derived from local erosion of the till and other deposits enclosed in the till.

Sediment in the St. Clair River is transported by suspension (suspended sediment) and by rolling along the bed (bedload transport). The size of material transported by each method is a function of the flow velocity in the river. Fine sands, silts and clays are carried in suspension whereas medium and coarse sand is transported as bedload. The gravel-sized fraction which occurs on the bed of the St. Clair River is too coarse for bedload transport (Rukavina 1986).

The rates of sediment transport by both processes were measured at ten stations 50 to 70 m (164 to 230 ft) apart and extending across the river on each of three transects offshore of the Sarnia industrial complex

Table 5.2 Depth of unconsolidated sediment and sediment type for 1986 sediment cores on the side of the St. Clair River downstream of Sarnia (Sediment Workgroup 1987).

Approximate Distance Downstream from Industrial Complex (km)	Distance from Shore (m)	Sediment Depth (cm)	Sediment Description
0	25	0	clay
2	50	2	sand/gravel
4	50	2	sand
8	50	4	sand/gravel
10	50	5	sand/gravel
12	50	2	sand/gravel
14	25 50	8 6	sand/gravel sand/gravel
20	35 50	1 0.5	sand sand
22	50 150	>10 16	sand sand/gravel
24	70 100	>12 >30	sand sand
26	25 50	>32 >14	sand/clay sand
28	25 50	6 1	sand/gravel sand
30	25 50	0 1	clay sand
32	25 50	>32 4	sand sand

(Sediment Workgroup 1987). The results are shown in Table 5.3. Total suspended load was measured at the same time as bedload, the latter using an Arnhem basket sampler. The quantity of bedload transport in this portion of the river is very small with the suspended sediment load approximately three orders of magnitude greater than the estimated bedload transport. The total sediment load carried by the river is important to determine with regard to contaminant transport through the river (Chapter 6). This information can be used to compare to other transport mechanism (i.e., in water and biota) when developing remedial strategies.

Figure 5.5

St. Clair River Remedial Action Plan

Unconsolidated sediment thickness on Canadian side of St. Clair River near Sarnia

(Rukavina 1986)

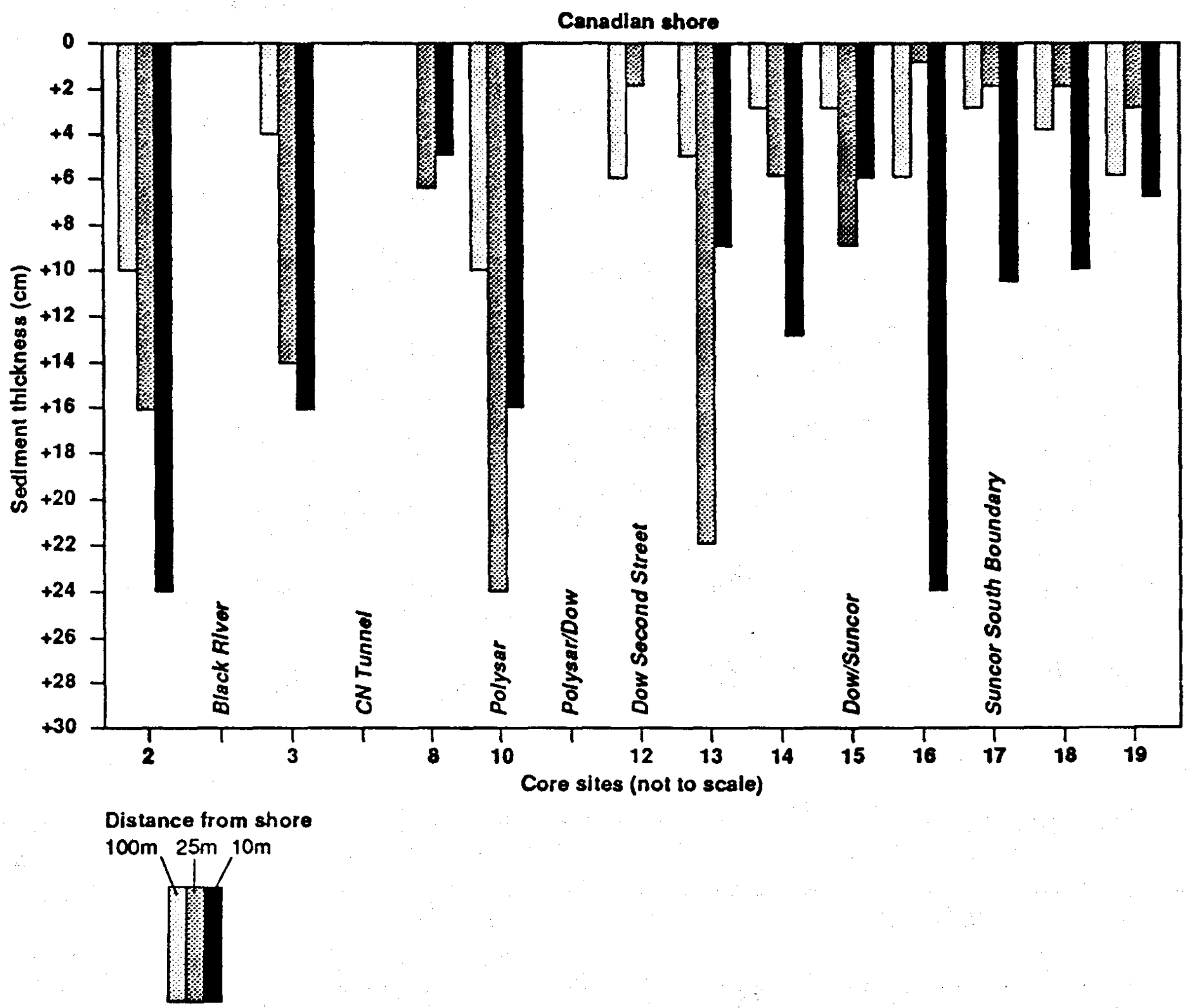


Table 5.3 Transport of sediment by bedload and suspended load and model calculations of river bedload based on averages of thirty sample locations (10 stations on each of 3 transects) on the St. Clair River in May, 1986 (from Sediment Workgroup 1987).

Site	Bedload Transport (tonnes/day)	Suspended Sediment (tonnes/day)	Potential River Bedload Carrying Capacity (tonnes/day)
Imperial	0.670	2,600	11,000
Dow	3.000	3,000	7,400
Port Lambton	3.600	2,600	3,800

Due to the river's high velocity (Figure 5.3), its capacity to transport material as bedload is more than three orders of magnitude greater than the actual observed transport rate, indicating that bedload transport is supply-limited (i.e., there is less sand entering from Lake Huron than the river is capable of transporting as bed load) (Sediment Workgroup 1987). The data shown in Table 5.3 represent only one sampling event conducted in the Spring (May 1986). However, suspended sediment loads are known to be extremely variable over the year and from year to year, being dependant on weather and river current conditions (Edsall et al. 1988a). Sediment loads are highest at the head of the St. Clair River (54,700-61,600 m^3/yr or 19.3 to 21.7 X 10^5) and lowest downstream (19,900 m^3/yr or 7.0 X 10^5) in the area of the delta, due to lower gradients where the river enters Lake St. Clair (Edsall et al. 1988a). The lower gradient in this area results in decreased river velocity and consequent deposition of the suspended sediment load.

5.5 GEOLOGY, GEOMORPHOLOGY AND SOILS

5.5.1 Bedrock Geology

The St. Clair River lies on the eastern rim of the Michigan Basin. Figure 5.6 illustrates the stratigraphic succession of bedrock formations in the vicinity of the St. Clair River. This area is typified by consolidated sedimentary rocks of Precambrian and Paleozoic origin, overlain by a thin layer of unconsolidated glacial deposits. The overlying glacial deposits vary in thickness from about 30 m to 75 m (98 to 246 ft). The sedimentary strata were deposited during the Devonian, Silurian, Ordovician and Cambrian periods (360 to 570 million years old), extend to an average depth of 1,350 m (4,428 ft) (Intera, 1989). Beneath this lies igneous and metamorphic Precambrian rock. The sedimentary deposits consist primarily of limestone, dolomite, salt and gypsum with minor shale and sandstone. They dip very gradually west to southwest toward the centre of the Michigan Geologic basin. Hydrocarbons have long been extracted from Devonian deposits in the area surrounding the St. Clair River. In fact, the first oil field in North America was established in 1858 at Oil Springs, Ontario, a community located about 25 km (15.5 mi) east of the St. Clair River (UGLCCS 1988, p.224). Rock salt (halite) occurs primarily in the Silurian Salina Formation (Figure 5.6) and has been mined at St. Clair, Michigan for several decades. These deposits have also played an important role in the economic development of the area.

5.5.2 Hydrogeology

Groundwater zones in the vicinity of the St. Clair River AOC include those of: (1) the overlying clay till (2) a zone of sand and gravel lenses and fractured bedrock at the interface between the till and underlying bedrock (freshwater aquifer); and (3) individual bedrock strata (bedrock aquifers).

Figure 5.6

St. Clair River Remedial Action Plan

Stratigraphy of bedrock formations in the vicinity of the St. Clair River

Era	Period	Group	Formation Ontario	Formation Michigan	Lithology
*			glacial deposits	glacial deposits	clays, sands, gravels
Paleozoic	Devonian		Port Lambton Kettle Point	Coldwater Sunbury, Berea, Bedford Antrim	shale shale, sandstone, shale shale
			Ipperwash Petrollia Widder Olentangy (Hamilton)	Traverse	limestone shale limestone shale
			Dundee	Dundee	limestone
		Detroit River	Lucas Amherstburg Sylvania Bois Blanc	Lucas Amherstburg Sylvania Bois Blanc	dolomite limestone sandsone dolomitic limestone
	Silurian		Bass Islands	Bass Islands	dolomite with shaly interbed
			Salina	Salina G F E D C B A-2 A-1	shaly dolomite shaly dolomite, anhydrite, salt dolomite with shaly interbeds anhydrite, salt shale, dolomitic shale anhydrite, salt dolomite, salt, anhydrite limestone, dolomite, anhydrite
			Guelph-Lockport	Guelph-Lockport	dolomite
			Rochester	Rochester	dolomitic shale

• Pleistocene Era

Ordovician period formations of Paleozoic Era are not shown.

Note: Stratigraphic units are the same in Michigan and Ontario. However nomenclature may be different.

The clay till is an aquitard which serves as a confining layer above the freshwater aquifer. It was described by Cherry et al. (1987) as till consisting of soft to firm grey clay with very low permeability. Groundwater movement is predominantly downward through the clay to the underlying bedrock, although shallow groundwater in the upper fractured portions of the till contribute up to 10 percent of the base flow in streams and rivers (UGLCCS 1988). Groundwater velocity in the relatively impervious unfractured till is in the order of 0.1 to 0.2 cm/yr (0.039 to 0.078 in/yr) (Cherry et al. 1987).

The freshwater aquifer includes the upper 1 to 2 m (3.3 to 6.6 ft) of fractured bedrock and a thin discontinuous layer of sand and gravel in contact with the bedrock (Intera 1989). This is the aquifer which is utilized for rural drinking water supplies in Lambton County, Ontario although there are no users in the immediate area of Sarnia (Intera 1989). Flow in this aquifer, in both Ontario and Michigan, is dominantly toward the St. Clair River (Intera 1989). Its average hydraulic gradient is 315 m/yr (1,033 ft/yr) (Intera 1989). Water quality is variable with average or background chloride concentrations of 60 to 1,280 mg/L, conductivity of 300 to 4,200 μmhos, dissolved organic carbon of <0.1 to 2.2 mg/L, and phenols at or below detection (1 μg/L) (Intera 1989).

There are several bedrock formations with varying water quality and hydraulic conductivities. Intera (1989) describes groundwater characteristics in the Kettle Point Formation, Hamilton Group of formations, Dundee Formation, Detroit River Group of formations, and the Bois Blanc, Bass Islands and Salina Formations. Generally the limestone units have the highest hydraulic conductivities. High permeability zones within the Detroit River Group were utilized prior to about 1974 for the pressurized disposal of liquid industrial wastes in the Sarnia area.

5.5.3 Geomorphology and Physiography

On the Ontario side of the river, the bedrock surface slopes gently southwest towards the river. A bedrock valley occurs parallel to the river, but is filled with glacial deposits; accordingly, it is not evident at the surface (Intera 1989). On the Michigan side of the river, the bedrock surface slopes gently eastward towards the river. While the bedrock surface is dissected by erosional valleys, these are filled with glacial deposits which are not expressed at the surface. There are no bedrock outcrops in this area due to the thickness of glacial and glaciolacustrine deposits.

The surface landforms and topography in both Michigan and Ontario are dominated by glacial deposits which were laid down during the Pleistocene epoch. During this time at least four different continental ice sheets inundated most of Canada and the northern U.S. The most recent glaciation is referred to as the Wisconsin. The principal glacial deposits in the St. Clair River AOC are a series of flat-lying till sheets overlain by discontinuous glaciolacustrine deposits. The entire AOC is included in a broad low-relief physiographic region which, in Ontario, is named the St. Clair clay plains (Chapman and Putnam 1984). Bevelled till plains (i.e., tills which are wave-modified by the glacial lakes) are the dominant surficial landform feature throughout most of the area. In Lambton County, these consist of clay (40-50%), sand (10%) and silt (Intera 1989). Immediately north of the St. Clair delta the till is overlain by a thin sheet of fine-grained glaciolacustrine clay and silt. These were deposited in post-glacial lakes Whittlesey and Warren which, at their highest stages, completely inundated the vicinity of the AOC (Chapman and Putnam 1984). The area of the delta is dominated by silts and fine sands of deltaic and glaciolacustrine origin.

A series of moraines parallel the Lake Huron shoreline in Ontario. Of these, the Wyoming Moraine extends the furthest south. It forms a single broad ridge which extends toward the St. Clair River but disappears west of Wyoming Ontario, approximately 20 km (12.4 mi) east of the river. There are no major moraines within the Michigan portion of the AOC. The only other deposits of any significance are alluvial sediments which are laid down along streams and rivers draining into the St. Clair River.

The St. Clair River and its extensive delta were formed after the retreat of the Wisconsin ice sheet, about 13,000 years ago. The weight of the ice greatly depressed the Earth's crust. As the ice retreated the land uplifted resulting in rapidly-changing lake levels thoughout the area of the Great Lakes' basin. A combination of glacial uplift, the uncovering of lower drainage channels (as the ice melted) and erosion caused water levels in these glacial and post-glacial lakes to oscillate by over 100 m (330 ft) with levels both much higher and much lower than present (Sly and Lewis 1972). The present level of Lake Huron was not established until after about 2,500 years ago.

5.5.4 Relief

The dominant surficial features in the region consist of till plains and former lakebeds. The occupation of the till plains by post-glacial lakes has had a levelling effect on the area's already low relief; in this regard, uplands have been diminished through wave action, and depressions filled by glaciolacustrine sediments. Accordingly, the area now is relatively flat with a distinctly subdued relief pattern. A low bluff near Bickford, Ontario, marks the shoreline of a post glacial lake. This is the only distinguishing surficial feature in the area surrounding the AOC, lying between 175 m and 213 m (574 and 698 ft) above sea level (UGLCCS 1988). Local variations in elevation do not usually exceed 3 m to 5 m (9.8 to 16.4 ft), with grades generally in the order of 0 to 3 percent.

5.5.5 Soils

A number of broad soil groups are recognized along the shoreline of the St. Clair River. These reflect the area's late Quaternary history as well as the distribution patterns and characteristics of the glacially derived parent materials.

Soils occurring directly at the outlet of Lake Huron belong to a group known as the Plainsfield sands. These are derived from sandy outwash; as a consequence, they tend to be coarse and well drained. However, most of the river passes through lands covered by various clay soils. These include Brookston and Perth clays, both of which originated from the clay till that underlies most of the region, and Caistor clays, which are derived from shaley clay till. All three groups are improperly drained due to a combination of poor relief, and the impermeability of the substrate itself.

Berrien sandy loams cover a small area just north of Walpole Island. These were formed from shallow sandy outwash overlying deep clay till. Due to the high compaction of the subsoils, this group is also generally imperfectly drained.

The soils of the St. Clair Flats are derived from the shores of Lake Huron. Consequently, they tend to be much coarser than the clay till soils seen along the majority of the river's shoreline. Two soil types dominate the delta (Herdendorf et al. 1986). A fine sandy loam occurs at its most highly elevated point. This soil type is known as the Colwood fine sandy loam in Ontario and as Sanilac loam in Michigan. It was formed in limey, water-laid, sandy loam sediments and is usually poorly drained. Within the wetlands proper, occurs a broad group of soils collectively called marsh soils in Ontario and Bach loam soils in Michigan. These have a very fine sand loam texture and are typically waterlogged. They were formed in limey, lacustrine, sandy clay sediments. Peat accumulations in the St. Clair Flats are minimal, as are organic rich soils.

5.6 VEGETATION, ZOOPLANKTON AND BENTHIC FAUNA

5.6.1 Terrestrial Vegetation

Land areas of the St. Clair River shoreline and flats can be divided into two biological zones: upland zones and transitional zones, both of which are normally above the water table, but which may be flooded periodically. Tree species which are either currently found, or were once seen, in the upland regions surrounding the St. Clair River are listed in Appendix 5.1. A similarly diverse complement of shrubs, herbs and grasses exists in this area. Woodliffe (1988) summarized the rare vascular plants of the Walpole Island Indian Reserve. These are provided in Appendix 5.2.

Much of the AOC's surrounding area upland forests have been cleared for agricultural or industrial purposes, or urbanization. Remaining stands are found mainly along the southern reaches of the river, particularly on the islands of the St. Clair Delta. The upland region bordering the St. Clair River consists of the Deciduous Forest Region with many species at or near their northern limit. Stands of oak-ash hardwoods can be found in the northern portions of Dickinson, Harsens, St. Anne, Squirrel and Walpole Islands, at elevations of 1 m to 3 m (3.2 to 9.8 ft) above the St. Clair Lake level (Herdendorf et al. 1986). Major species of this forest region originally included beech, sugar maple, basswood, red maple, red oak, white oak and buroak (Rowe 1972). Other species which occurred sporadically included black walnut, sycamore, swamp white oak, shagbark hickory, butternut, bitternut hickory, rock elm, silver maple, blue beech, sassafras, tulip-tree, black cherry, mockernut and pignut hickories, chinquapin oak, pin oak, black oak, black hum, blue ash, cucumber-tree, pawpaw, Kentucky coffee-tree and red mulberry. Conifers are generally poorly represented with eastern hemlock, white pine, eastern red cedar and eastern white cedar being present (Rowe 1972).

Prairie species from the midwestern United States, which occur discontinuously through Michigan into adjacent areas of southwestern Ontario, have resulted in the occurrence of several graminoid and forb species which occasionally produce tall-grass prairie communities and complexes. Examples of these communities are found on Walpole Island, Dickenson Island and the St. John's Marsh. The upland shrub community consists of a variety of water-tolerant species including eastern cottonwood, quaking aspen, red ash, red osier dogwood, gray dogwood, wild grape and hawthorn.

Transitional species are abundant in the low-lying regions of the St. Clair River and its flats; species common to this area are listed in Appendix 5.3. This transitional zone can be divided into four broad classes: shrub ecotones, wet meadows, sedge marshes, and island shorelines and beaches (Herdendorf et al. 1986).

<u>Shrub ecotones</u> represent a transition into upland forests. The depth of the water table in these areas is typically 0.5 m to 1 m (1.6 to 3.3 ft) and flooding is rare. The communities are composed of mixed shrubs, water-tolerant trees and some understorey plants typical of meadows (Herdendorf et al. 1986), including eastern cottonwood, quaking aspen, red ash, red-osier dogwood, gray dogwood, wildgrape and hawthorn (Edsall et al. 1988a). During low-water periods, invasion into sedge marshes occurs. However, when water levels are high, as occurred during the 1970s, these areas are flooded, resulting in the dieback of woody plants. Shrub ecotones occur on Dickinson and Harsens Islands, landward of the wet meadows.

<u>Wet meadows</u> occur transitionally between sedge marshes and the upland hardwood community. This zone lies just above the water table and is rarely flooded (Herdendorf et al. 1986). It includes a range of water tolerant trees, shrubs, herbs and grasses. The dogwood meadows of the St. Clair Flats are an example of the wet meadow ecotone. The principal species in these communities are bluejoint grass, swamp milkweed, soft rush, fowl meadow grass, gray dogwood, rice cutgrass, quaking aspen, tussock sedge, red ash, red-osier dogwood, swamp rose, rattlesnake grass, panic grass, marsh fern, silverweed, and goldenrods (Edsall et al. 1988a).

<u>Sedge marshes</u> form narrow zones between cattail marshes and the more terrestrialized upland zone. They are also seen along the river channels, at the base of old shorelines which have been stranded by cattail marshes, and at the edge of eroding lake and bay shorelines (Herdendorf et al. 1986). This community occurs in wet areas which undergo periodic flooding, but where permanent water depths do not exceed 15 cm (6.0 inches). Typical residents of this community are nearly all members of the tussock sedge group, blue jointgrass, common comfrey and night shade (Edsall et al. 1988a).

Island shorelines and beaches form the last terrestrial community type. Species grow in discontinuous, sandy habitats, raised slightly above the water table (Herdendorf et al. 1986). Narrow beaches of fine, shallow sands which support emergent vegetation occur along the Canadian side of the St. Clair Flats. Beach ridges also occur on the flats, and can be up to 100 m (328 ft) in width. These communities support a wide variety of vascular plants including tussock sedge, reed canary grass, swamp thistle, bluejoint grass, willows, eastern cottonwood, staghorn sumac, touch-me-not swamp thistle, stinging nettle, morning glory and black bindweed (Edsall et al. 1988a).

While none of the terrestrial plant species found in the St. Clair River and flats are known to be endangered, the Michigan government has designated a number of species as threatened. For Harsens Island, marsh sedge, prairie fringed orchid, Hill's thistle, panic grass and sand grass are all considered threatened (Herdendorf et al. 1986). Weise (pers. com.) reports the following state listings for species on Harsens Island: marsh sedge, special concern; prairie fringed orchid, endangered (federal threatened list); Hill's thistle, special concern; panic grass, threatened; and sand grass, special concern.

5.6.2 Aquatic Vegetation, Zooplankton and Benthic Fauna

5.6.2.1 Phytoplankton

According to Edsall et al. (1988a), there are few data on the phytoplankton community of the St. Clair River. What is known indicates that the phytoplankton composition is dominated by diatoms occurring in patterns similar to that of Lake Huron. The dominant species include *Cyclotella spp.*, *Fragilaria spp.*, *Melosira spp.*, *Stephanodiscus spp.*, *Synedra spp.* and *Tabellaria spp.*

Typical phytoplankton species occurring in southern Lake Huron have been identified from sampling at the Lambton Water Treatment Plant. *Synedra spp.*, *Rhizosolenias spp.*, *Melosira spp.*, and *Cyclotella spp.* are important components of the phytoplankton, developing almost exclusively during the spring months (Michalski 1975). Although highest numbers of *Fraqilaria spp.* and *Tabellaria spp.* also occur during spring, these plankters are encountered regularly over the year. *Dinobryon spp.*, the most important chrysophyte, developed during the late spring, summer and fall months. The dominant blue green algae are *Oscillatoria spp.* and *Aphanothece spp.*, while the chlorococcolean phytoplankton most often enumerated include *Oocystis spp.*, *Ankistrodesmus spp.*, *Scenedesmus spp.*, *Coelastrum spp.*, *Chlamydomonas spp.*, *Cruciqenia spp.*, *Kirchneriella spp.* and *Laqerheimia spp.*

5.6.2.2 Zooplankton

The community is dominated by fugitive drift species from Lake Huron (Edsall et al. 1988a). The composition of the zooplankton include 18 rotifer genera, 9 calanoid copepods, 4 cyclopoid copepods and 6 cladocerans (Edsall et al. 1988a). The dominant zooplankton consist of rotifers, the cladoceran *Bosmina longirostris* and the copepods *Diacyclops thomasii* and *Diaptomus minutus* (Edsall et al. 1988a).

The open water areas of the St. Clair River have relatively low densities of zooplankton (Edsall et al. 1988a). The only quantitative information on densities within the river is provided by a single study conducted in 1974 in the vicinity of the Detroit Edison Co. plant, upstream of Marine City (Texas Instruments 1975). Densities of 50 individuals/m^3 (1,764/ft^3) in May increased exponentially over the summer, peaking at 4,000 individuals/m^3 (141,150/ft^3) in August. Densities then declined to between 300 and 500 organisms/m^3 (10,600 and 17,650/ft^3) in September and remained at this level through December.

5.6.2.3 Benthic Invertebrates

The taxonomic diversity of benthic invertebrates in the St. Clair River includes at least 179 taxa (Griffiths et al. 1991) which is intermediate between that of typical Great Lakes shore zones (334 taxa) and Lake St. Clair (65 taxa) or the Detroit River (80 taxa) (Edsall et al. 1988a). The most common species of benthic invertebrates in the St. Clair River represent the Nematoda (round worms), Oligochaeta (aquatic worms), Amphipoda (crustaceans), Diptera (true flies, chironomids), Ephemeroptera (mayflies), Trichoptera (caddisflies), Gastropoda (snails) and Pelecypoda (clams and mussels) orders. Common chironomid species include *Cryptochironomus spp.*, *Procladius spp.* and *Tribelos spp.* The most common amphipod is *Gammarus fasciatus* and dominant trichopteran include *Hydropsyche spp.* and *Cheumatopsyche spp.* (Griffiths et al. 1991). The most common mayflies are *Hexagenia spp.* and *Caenis spp.* Fresh water mussels are present, however, the fingernail clams *Pisidium spp.* and *Sphaerium spp.* may be the most abundant bivalves in the St. Clair River. The zebra mussel (*Dreissena polymorpha*) is an exotic species which is rapidly increasing in abundance in the river. With few natural predators, this mussel could cause substantial damage to the sport and commercial fisheries as well as water intake and outlet pipes related to industrial and municipal facilities (OMNR 1990). The Asiatic clam (*Corbicula fluminea*) has also been reported from the river (French and Schloesser 1990) and, similar to the zebra mussel, may also clog water intake and outlet pipes in the river.

The 179 macrozoobenthic invertebrate species listed by Griffiths et al. (1991) were identified in the St. Clair River from surveys conducted in October 1976; March, May and October 1977; May and July 1977; May and October 1983 and 1984; and May 1985. They predicted that species richness is actually much greater, likely consisting of more than 300 taxa, because the capture methods employed were size-selective for larger invertebrates, and the identification of immature organisms to the species level was often impossible. Further, many organisms including sphaerid clams, nematodes, flatworms, benthic cladocerans and copepods were not always identified to the species level. Griffiths et al. (1991) listed only 23 species of freshwater molluscs; in contrast, Herdendorf et al. (1986) listed 112 species for the marshes, nearshore waters and tributary mouths of Lake St. Clair based on several studies which spanned a much greater time period (approx. 1930 to 1980).

Most of the species listed by Griffiths et al. (1991) showed little seasonal variation, with capture equally likely in any of the months in which sampling occurred. Site-specific seasonal factors, such as the growth of macrophyte beds, did not seem to affect their occurrence.

Twenty-four species of benthic macroinvertebrates were commonly found within the nearshore areas at depths <8 m (<26.3 ft) of the St. Clair River; these are listed in Table 5.4. All species were found at 40 percent or more of the sites sampled. The habitat preferences of the various species are shown in Table 5.5. Griffiths (1989) divided the river into four habitat types, each of which contained distinct assemblages of benthic macroinvertebrates:

1. "psammon", is a unique habitat type found at the head of the St. Clair River. It is characterized by a substrate that consists almost entirely of sand, and which is low in organic carbon and nutrients; it is dominated by the small-bodied, highly specialized chironomids *Chernovskiia spp.* and *Saetheria spp.*;
2. "erosional" habitat, is characterized by swift-flowing water, coarse sediments and little organic matter. It occurs upstream of Stag Island in the upper quarter of the river, and along bends, and is dominated by the caddisflies *Cheumatopsyche spp.* and *Hydropsyche spp.*, the snail *Elimia livescens* and flatworms.
3. "run" habitat, is typified by intermediate flow and sandy-silt sediments; it is the most common type of habitat within the St. Clair River, occurring from Point Edward to Lake St. Clair. Its benthic fauna is characterized by the mayfly *Caenis spp.*, the ampipod *Gammarus fasciatus*, *Amnicola spp.* and a variety of other snails, and the worms *Limnodrilus hoffmeisteri* and *Spirosperma ferox*, and;

Table 5.4 Occurrence of common benthic macroinvertebrates taxa at 78 nearshore sampling sites (<8 m) in the St. Clair River, May 1985 (from Griffiths et al. 1991).

Species	% Occurrence
CADDISFLIES	
Hydropsyche	50
Cheumatopsyche	40
MAYFLIES	
Hexagenia limbata	45
Caenis	40
TRUE FLIES	
Cryptochironomus	67
Polypedilum	65
Procladius	65
Tribelos	45
AMPHIPODS	
Gammarus fasciatus	68
SNAILS	
Amnicola	77
Elimia livenscens	68
Physella gyrina	67
Valvata tricarinata	49
V. piscinalis	46
Gyraulus	41
CLAMS	
Pisidium	77
WORMS	
Limnodrilus hoffmeisteri	83
Spirosperma ferox	74
Quistadrilus multisetosus	59
L. udekemianus	42
Potamothrix moldaviensis	42
L. claparedianus	40
Stylodrilus herringianus	40
FLATWORMS	
Turbellaria	63

Table 5.5 Densities of common macroinvertebrates (mean number/cm^2) of four nearshore benthic assemblages reported by Griffiths (1989) in the St. Clair River, May 1985. (from Griffiths et al. 1991).

Species	Habitat Assemblage[1]			
	Psammon	Erosional	Run	Depositional
CADDISFLIES				
Cheumatopsyche		7.7	P[2]	P
Hydropsyche		1.8	P	P
Protoptila masculata		1.0		
MAYFLIES				
Caenis		1.2	4.5	1.2
Hexagenia limbata		P	2.8	12.3
Stenonema		1.2	P	
TRUE FLIES				
Chernovskiia	3.4			
Chironomus	P		1.8	13.3
Cryptochironomus	2.1	P	8.8	33.0
Harnischia			1.0	4.6
Paracladopelma		P	P	2.6
Polypedilum		P	16.2	30.7
Saetheria	3.0			
Stictochironomus			2.7	7.9
Tanytarsus		P	3.5	15.3
Tribelos		P	18.0	13.7
Monodiamesa	P	P	1.0	4.0
Procladius		P	11.3	67.1
AMPHIPODS				
Gammarus fasciatus		1.4	6.2	4.4
CLAMS				
Pisidium	P	P	6.2	5.5
SNAILS				
Amnicola		P	9.4	2.2
Physella gyrina		1.0	2.7	P
Gyraulus		P	1.8	P
Elimia livescens		6.4	2.6	P
Valvata piscinalis		P	3.2	
V. tricarinata		P	3.6	P
WORMS				
Stylodrilus		P	1.2	P
Limnodrilus claparedianus		P	3.7	3.9
L. hoffmeisteri		3.8	31.2	12.3
L. udekemianus		P	1.4	3.1
Potamothrix moldaviensis			1.1	3.4
Quistadrilus multisetosus			2.6	8.9
Spirosperma ferox		P	17.3	9.6
FLATWORMS				
		4.5	4.3	2.5
Mean richness (# taxa/cm^2)	2.6	8.9	15.3	17.5
Mean density (#/cm^2)	9.9	47.3	216.6	331.9

[1] See text for description and approximate locations of habitat types.
[2] P denotes a mean density of < 1

4. "depositional" habitat, which occurs in areas of quiet flows, where fine silty sediments and organic matter accumulate. This habitat hosts the mayfly *Hexagenia limbata*, a variety of chironomids including *Procladius spp.*, *Cryptochironomus spp.* and *Polypedium spp.* and the worms *Quistradrilus multisetosus*, *Limnodrilus claparedianus*, *L. udekemianus* and *Potamothrix moldaviensis*. This assemblage is located primarily in the lower quarter of the river (downstream from Fawn Island), and in Sarnia Bay.

Species changes along the length of the river largely reflect changes in habitat type and feeding method relationships (Griffiths et al. 1991). The upstream portions of the river receive organic matter from a variety of sources. For example, phytoplankton from Lake Huron, is utilized by organisms (*Cheumatopsyche spp.* and *Hydropsyche spp.*) adapted for filter-feeding; internally produced periphyton is utilized by invertebrates adapted for scraping (mainly *Elimia livescens*), and detritus, which is produced both internally and externally, is utilized by organisms adapted for gathering (worms and chironomids). Filter-feeders and scrapers are relatively abundant near the head of the river and decrease in abundance downstream. The downstream community, represented primarily by gatherers, utilizes the abundant detrital resource produced internally by dying macrophytes. The increasing productivity of downstream macroinvertebrate assemblages thus appears to be related to the internal production of organic matter by the macrophyte community (Griffiths et al. 1991).

The 10 major macroinvertebrate taxa identified from the St. Clair River in 1977 are listed in Table 5.6. Oligochaetes (aquatic worms) are found in greater numbers than any other group of benthic invertebrates. As noted above, together with chironomids, these are the dominant gathering organisms (Griffiths et al. 1991). Of the 10 major taxa in the St. Clair River, the Oligochaeta, Diptera (true flies), Gastropoda (snails), Amphipoda (crustaceans) and Pelecypoda (clams, mussels) were the most abundant. Mean densities of these 5 taxa in the river exceeded those of Lake St. Clair by up to half an order of magnitude (Table 5.6).

Table 5.6 Density (mean number/m^2) of 10 major taxa of benthic macro-invertebrates in the Lower St. Clair River and Lake St. Clair in 1977 (after Hiltunen 1980 and Hiltunen and Manny 1982).

Taxon*	St. Clair River	Lake St. Clair
Nematoda	424	596
Oligochaeta	7,680	1,983
Polychaeta	0	801
Amphipoda	513	418
Ispopoda	33	175
*Diptera***	3,039	582
Ephemeroptera	99	128
Trichoptera	42	0
Gastropoda	843	333
Pelecypoda	495	331

* Hydra were abundant but not enumerated.
** About 95% were *Chironomidae*.

Three groups of insects are abundant: the orders Diptera, Ephemeroptera and Trichoptera. The order Diptera (true flies) is almost entirely represented by chironomids. The order Ephemeroptera (mayflies) is dominated by *Hexagenia spp.* (63%) and *Caenis spp.* (31%) (Table 5.7). *Hexagenia spp.* can reach densities of up to 3,000 nymphs/m^2 in the river's lower reaches. *Cheumatopsyche spp.*, *Hydropsyche spp.* and *Oecetis spp.* represent most of the order Trichoptera (caddisflies) (Table 5.8).

Table 5.7 Densities of *Ephemeroptera* in the St. Clair River in 1983-1984 (after Hudson et al. 1986).

Genus	Mean Number/m^2
Baetis	T
Baetisca	6
Caenis	223
Ephemerella	22
Hexagenia	447
Stenacron	A
Stenonema	15
Tricorythodes	T

T = Trace (i.e., <0.5/m^2)
A = Adult

The phylum mollusca is represented by members of the taxa Gastropoda (snails) and Pelecypoda (clams and mussels). The most abundant snails are *Amnicola spp.*, *Elimia livescens* and *Physa spp.* representing 52, 18 and 11 percent of the total, respectively (Edsall et al. 1988a); the dominant clam is *Pisidium spp.* (Table 5.9).

Non-native benthic macroinvertebrates are abundant within the St. Clair River. These include the faucet snail (*Bithynia tentaculata*), the European valve snail (*Valvata piscinalis*) and the Asian clam (*Corbicular fluminea*) (Griffiths et al. 1991). Another exotic species, the zebra mussel (*Dreissena polymorpha*) also occurs and is expected to become more abundant in the river, particularly where flow rates are below 1.0-1.5 m/sec (Jenner 1983). This exotic can alter carbon flow and may affect the movement of organic contaminants through the food web.

5.6.2.4 Macrophytes

Aquatic macrophytes can be divided into two broad groups: submergent macrophytes, which grow completely beneath the water's surface, and emergent macrophytes, which are rooted beneath the surface, but which extend aerially. Collectively, these two groups of plants are the main primary producers in the St. Clair system (Edsall et al. 1988a). As well, they provide cover and food for fish and waterfowl (Appendix 5.4), and can also serve as a substrate for periphyton (algae which are attached to rocks, docks, branches and other plants), and for invertebrates fed upon by fish and waterfowl. They constitute critical habitat for primary and secondary production for plants, fish and birds (McCullough 1985). Additionally, their presence adds physical structure and habitat diversity to an environment that has been substantially modified by the creation of navigation-related features and structures. For example, snags, deadheads, debris, bank overhangs, shoreline edges and bottom substrates have been altered through dredging, filling and bulkheading. By reducing flow velocities as much as 80 percent in some sections of the river (Hudson et al. 1986), macrophyte beds have increased the deposition of organic matter, which is an important food source for aquatic invertebrates. According to Elwood et al. (1983), this retention increases productivity in the river by reducing or shortcircuiting the food chain levels through which carbon and other nutrients are normally cycled. As well, they produce large quantities of organic matter (Edwards et al. 1989). Although most

Table 5.8 Densities of *Trichoptera* in the St. Clair River in 1983-1984 (after Hudson et al. 1986).

Genus	Mean Number/m^2
Branchycentrus	15
Ceraclea	9
Cheumatopsyche	68
Helicopsyche	S
Hydropsyche	65
Hydroptila	T
Limnephilus	A
Micrasema	T
Mystacides	7
Nectopsyche	1
Neureclipsis	18
Nyctiophylax	A
Oecetis	26
Orthotrichia	T
Oxyethira	A
Phylocentropus	T
Phryganea	T
Polycentropus	8
Protoptila	9
Pycnopsyche	T
Setodes	2
Triaenodes	3

S = Shell only
T = Trace (i.e., <0.5/m^2)
A = Adult

Table 5.9 Densities of *Pelecypoda* in the St. Clair River in 1983-1984 (after Hudson et al. 1986).

Taxon	Mean Number/m^2
Lampsilis	T
Pisidium sp.	280
Sphaerium sp.	19
Uniondae (juveniles)	T

T = Trace (i.e., <0.5/m^2)

macrophytes are absent during the winter and early spring, species of the family Characeae remain throughout the year to perform this function.

The macroflora within the Area of Concern is diverse. There are at least 18 submerged native macrophyte taxa and 3 submerged exotic taxa (Edsall et al. 1988a). The former consist primarily of *Chara spp.* (macroalga), *Vallisneria americana*, *Potamogeton richardsonii* and *Elodea canadensis*. Exotic species include *Potamogeton crispus*, *Nitellopsis obtusa* and *Myriophyllum spicatum*. The most important species for use by fish and wildlife include *Vallisneria americana*, *Elodea canadensis*, *Potamogeton richardsonii* and *P. crispus* (Edsall et al. 1988a).

Submerged macrophyte stands are typically composed of 2 to 3 species, although *Chara spp.* commonly occur in monotypic stands. Some stands contain up to 11 species (Edsall et al. 1988a). Aquatic macrophyte growths are usually confined to depths of less than 4.5 m (14.8 ft) with a maximum depth of 7.9 m (25.9 ft) for *Elodea canadensis*; however, the Characeae are commonly seen at depths up to 5.5 m (18 ft) with a maximum depth of 6.7 m (22 ft) and *Cladophora spp.* commonly grows to depths of 8 m (26.2 ft) with a maximum depth of 10 m (32.8 ft). No macroflora generally occur at depths greater than 10 m (32.8 ft) (Schloesser and Manny 1982).

Using the 4.5 m (14.8 ft) contour as a cutoff, there are approximately 2,000 ha (4,940 acres) of available macrophyte habitat within the St. Clair River, with much of it utilized. More specifically, it is estimated that 88 percent of the river bottom between depths of 0 m and 3.7 m (0 to 12.1 ft) which includes an area of 16 km^2 (6.2 mi^2) is utilized by plants (Edsall et al. 1988a).

Biomass drift, the drift of living plant material, occurs throughout the St. Clair River and may be important as a means of redistributing food resources. *Potamogeton spp.*, *Vallisneia americana*, *Potamogeton richardsonii* and *Chara spp.* are the most common species found in drift samples (Manny et al. 1988)

A study by Haas et al. (1985) indicated that the river contains a mixture of riverine and lake species. A comparison of biomass drift at Port Huron and Algonac indicates that far more plant material leaves the river than enters it as drift. Between April and October of 1986, approximately 893 metric tonnes (984 tons) ash-free dry weight left the river as surface drift. This is equivalent to 39 percent of the river's annual production of submersed macrophytes. Only two to three percent of this drift originated in Lake Huron.

Although emergent macrophytes colonize an estimated 3,380 ha (8,350 acres) of the St. Clair River, mostly in the lower portions, very little is known about their composition, abundance distribution, occurrence or productivity (UGLCCS 1988). Typical species known to occur include *Typha spp.* (cattails), *Phragnites australis* (reed), *Nuphar advena*, *Sagittaria latifolia* (arrowhead) and *Scirpus spp.* (bullrush) (UGLCCS 1988).

Estimates of total submerged macrophyte biomass for the St. Clair River range from 2,080 metric tonnes (2,292 tons) ash free dry weight to 2290 tonnes (2,524 tons) ash free dry weight (OMOE 1990a). These estimates were based on surveys undertaken in 1987 and 1983-84, respectively, and their agreement indicates the stability of the biomass production over this period. This is far less than the 22,620 metric tonnes/year (24,927 tons) ash-free dry weight emergent macrophytes produced annually.

There are four main types of aquatic plant communities in the St. Clair River and delta: open water communities, river channel communities, cattail marshes and abandoned river channel communities. Submergent and emergent macrophytes exist in each. These communities are described below in general terms. It is important to note, however, that their nature may change over time as waterlevels in the Great Lakes can fluctuate dramatically from year to year.

Open water communities are found along the St. Clair Delta, in bays, in abandoned channels and in open water areas within cattail marshes (Edsall et al. 1988a and Herdendorf et al. 1986). As well, there are a number of bays which have been cut off by siltation from the main channels that often support these types of communities. Water depths usually do not exceed 2 m (6.6 ft); hard-stem bulrush, wild celery, pickerel weed, buttonbush, yellow water lily, water smartweed, muskgrass or stonewort, Eurasian milfoil, hybrid cattail, three-square bulrush and sago pondweed are representative species in these communities (Edsall et al. 1988a). Open water communities on the Ontario side of Lake St. Clair were described by Planck (1984). She noted that these communities have waterfowl foods such as sago pondweed and wild celery which increase in amount following the removal of former emergent vegetation due to lake level changes. She also noted species such as muskgrass, greater burreed, hardstem bulrush, tussock sedge, purple loosestrife, tuberous water lily and spatterdock as occurring in the open water marsh.

River channel communities are abundant along St. Clair River shoulders and their distributary channels within the St. Clair Delta. River shoulders are submerged shoals where water depths do not exceed 2 m (6.6 ft), and the average width is about 35 m (115 ft) (Edsall et al. 1988a). Submergent aquatic plants, such as muskgrass, Canada waterweed, cattails, redhead grass, reed grass, water celery and various pondweeds and milfoils occur in the river channel community (Edsall et al. 1988a). Emergent macrophytes are occasionally seen on point bars.

Cattail marshes are found in broad zones along the lower portion of the St. Clair Flats, on inundated shoulders of river channels, in shallow embayments, and in areas which have been diked (Edsall et al. 1988a and Herdendorf et al. 1986). The southern end of Walpole Island is almost all cattail marsh. Water levels in these marshes can fluctuate as much as 60 cm (2 ft) but are generally within about 15 cm (6 in). Cattails dominate these wetlands, with hybrid stands common in areas with peaty or clay sediments. Bladderwort, little watermilfoil and various duckweeds are also common (Edsall et al. 1988a). Cattail marshes (emergent marsh habitats) on the Ontario side of Lake St. Clair consist predominately of cattails interspersed with a few meadow complexes of sedges with *Phragmites* spp. (Planck 1984). Other species in these emergent marshes include purple loosestrife, jewelweed and tussock sedge.

Abandoned river channel communities provide a unique habitat because they are sheltered, shallow and have silt of peaty sediments (Herdendorf et al. 1986). Water depths are generally less than 1 m (3.3 ft). Such habitats are seen on the upper portions of Harsens and Dickinson Islands, and contain a variety of submergent and emergent plants including yellow waterlily, white waterlily, little watermilfoil, common arrowhead, hard-stem bulrush and three-square bulrush. Occasionally, buttonbush is also present (Edsall et al. 1988a).

5.7 LAND USES

5.7.1 Introduction

On the Ontario side of the St. Clair River, no data are available which differentiate shoreline land uses types. However, on the Michigan side, residential development occupies about 42 km (26 mi) of shoreline, industrial and commercial uses account for another 10 km (6.2 mi) of frontage, publicly owned lands comprise 8.1 km (5.0 mi), and 5.5 km (3.4 mi) are dedicated to recreation and wildlife preserves (Acres International Limited, 1990). Current land uses are illustrated in Figure 5.7.

5.7.2 Agriculture

The St. Clair drainage basin, described in Section 5.1, is largely rural, with much of it in intensively managed farmland. On the Ontario side of the river, 78 percent of the 20,976 ha (51,810 acres) drainage basin of the St. Clair River is agricultural (Nonpoint Source Workgroup 1987a). This area is within Ontario's agricultural heartland, well-known for its long growing season and fertile soils. The principal enterprise is cashcropping, with 60 percent of the area's farms dedicated to this endeavour. Thirteen percent of the farms raise beef and another 6 percent are swine operations. Soybeans are the principal cashcrop, being grown on 40 percent of the area's total cropland. This is followed by corn (24%), wheat (18%), hay (12%) and cereals (3%).

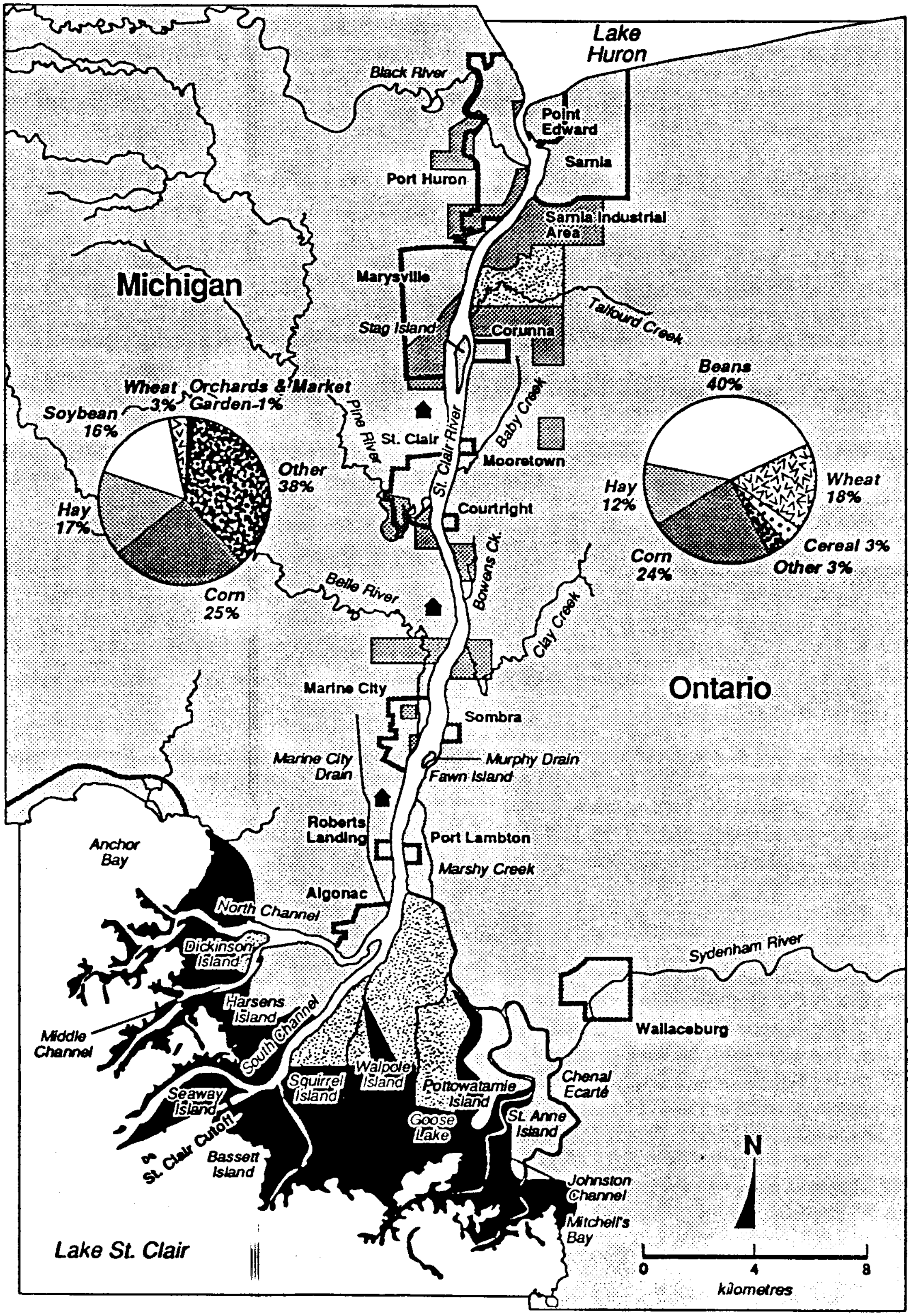
On the Michigan side, 68 percent of the 315,900 ha (780,600 acres) drainage basin is agricultural (Nonpoint Source Workgroup 1987b). The majority of this is in the counties of Sanilac (49%) and St. Clair (35%). There are 2,303 farms within this area. The remainder is in Lapeer (14%) and Macomb (<3%) counties.

Figure 5.7

St. Clair River Remedial Action Plan

Land use along the St. Clair River in Ontario and Michigan

(Acres International Inc. 1990)



mixed Carolinean forest and "wet" prairie

agriculture

wetlands

industry

residential / commercial

cottages / riverside residences

Again, cashcropping is the main enterprise, with 85 percent of the area being cropland (this varies from 35% in Macomb County to 88% in Sanilac County). Corn is the major crop, and is grown on 25 percent of the land area. Hay and soybeans are also important, being grown on 17 percent and 16 percent, respectively of the total cropland. Three percent of the cropland is dedicated to wheat, 0.8 percent is used to grow other vegetables and 0.2 percent is orchard. A total of 3.3 percent of cropland is irrigated. Six percent of the farmland is pasture, with beef and dairy operations both being important. There are more than 41,000 head of beef cattle and 22,000 dairy cattle raised in this area (58% of these cattle are in Sanilac County). The area also raises nearly 13,000 hogs and pigs, 2,300 sheep and lambs and 125,000 poultry (82% of which are raised in St. Clair County).

Agriculture has long been important to the native people of the area. Archaeological evidence suggests that crop planting occurred as much as 2,500 years ago (Nin.Da.Waab.Jig 1987). Nine hundred years ago corn, squash and tobacco were grown in summer settlements within the AOC vicinity. For the Walpole Island Indian Band, land surrenders between 1790 and 1827 caused them to turn from the more traditional activities of hunting and fishing to agriculture. There is currently over 4,000 ha (9,880 acres) of arable land on the Walpole Island Reserve. These lands are used chiefly for cashcropping. Nearly 1,800 ha (4,450 acres) are part of the band-operated farm, Tahgahoning, which is its major source of revenue, with profits of $600,000 in 1983 (Nin.Da.Waab.Jig. 1989). Tahgahoning provides full-time, year-round employment to seven band members and seasonal employment to many others.

5.7.3 Urban and Rural Population

The population of the Clair River drainage basin is concentrated primarily within urban centres located in a narrow zone along the river. Approximately 170,000 people live on or near the shores of the waterway. About 90,000 people live on the Canadian side, the other 80,000 on the American side. Much of this population is distributed between the cities of Sarnia, Ontario (population 46,400), and Port Huron, Michigan (population 47,300). Both are located near the head of the river. A number of smaller communities are scattered along the river's shoreline, including Point Edward Village (population 2,200), and the hamlets of Corunna, Courtright, Sombra and Port Lambton in Ontario, and Marysville (population 7,700), St. Clair (population 5,200), Marine City (population 5,400) and Algonac (population 11,000), in Michigan. Additionally, 11,500 people live in the City of Wallaceburg, located near the southeastern edge of the AOC on the Sydenham River (Acres Internatioal Ltd 1990).

As noted above, much of the area surrounding the AOC is rural. In Lambton County, 30,800 people (nearly 26% of the county's population) live in rural areas; this includes 9,900 in Moore Township and 2,500 in Sombra Township, two townships located near the St. Clair River AOC. In Michigan, 3,200 people live rurally in East China Township, on the river's shoreline.

5.7.4 Industry

Industrial development of the region was historically linked to the presence of the St. Clair River and to the area's geology. The river provided and continues to provide inexpensive transportation for goods and raw materials. The abundant water resource attracted thermal generating plants and other companies which require large volumes of processing water. Hydrocarbon and mineral resources were also important in bringing industry to this area, including Ontario's chemical and petroleum industries and Michigan's salt companies. Much of the area's industry is concentrated within an area known as the "Chemical Valley", between Sarnia and Corunna in Ontario. This area contains four petroleum refineries and organic and inorganic chemical manufacturers. Other important area industries include paper production, salt processing and thermal electric facilities. A more complete description of some of the principal industries in the area is provided in Section 5.8.7.1.

5.7.5 Native Lands

There are two Indian reserves on the Canadian side of the St. Clair River. The Chippewas of Sarnia Band Reserve, located between Sarnia and Corunna, had a 1986 population of 796 (Indian and Northern Affairs Canada 1988); in addition, there are 581 band members who do not live on the reserve. The Walpole Island Reserve, located on Basset, Walpole, Squirrel and St. Anne Islands, had 1,787 band members living on the reserve, and 807 living off the reserve (1986 data).

In addition to the community farm on Walpole Island, Band members also operate Walpole Industries, a tool and die shop, which is both a training centre and a source of employment for 22 full-time persons. Hunting and fishing are important to Band members, not only for food, but also for the income generated through land leases and from guiding. Trapping is also an important source of income for some.

5.7.6 Recreation

The St. Clair River is a popular summertime destination for tourists. Its accessibility to several large urban centres, proximity to Lake Huron and Lake Erie, clear waters and good fishing have all led to this popularity. In Ontario, the St. Clair Parkway Commission oversees 19 parks along the river, occupying a total of approximately 200 ha (500 acres); these provide campgrounds, day-use parks, and marinas. On the Michigan side, Algonac State Park, and the Michigan State Waterways Commission harbours at St. Clair and Port Huron respectively provide similar recreational amenities (Figure 5.8).

There are 607 overnight public campsites on both sides of the river, which have traditionally catered to an estimated 191,000 camper-days per year. However, during the summers of 1988 and 1989, the Algonac State Park and St. Clair Parkway Commission have recorded small reductions in camper activity. The 191,000 camper-days per year corresponds to a total expenditure of U.S. $2 million in 1989 dollars, including local spending of approximately U.S. $356,000 (Acres International Limited 1990).

In 1989, Algonac State Park received an estimated 84,252 day use visitors, corresponding to an expenditure of some U.S. $1.4 million in 1989 dollars. This level of use is associated with local expenditures of about U.S. $450,000. (Acres International Limited 1990). Comparable data on St. Clair Parkway Commission day users are not available.

There are many cottages along both sides of the river and several beaches occur along the river's length, including eight in parks operated by the St. Clair Parkway Commission. Centennial Park in Sarnia offers a beach as well as other recreational opportunities. The number of beaches on the U.S. side of the river is unknown. Edsall et al. (1988a) reported that beach use along the river is minimal. This is probably due to the proximity of other popular areas like the Pinery Provincial Park and Lakeport State Park, both located at the southern end of Lake Huron, an area noted for its quality beaches.

5.7.7 Forests and Wetlands

5.7.7.1 Forests

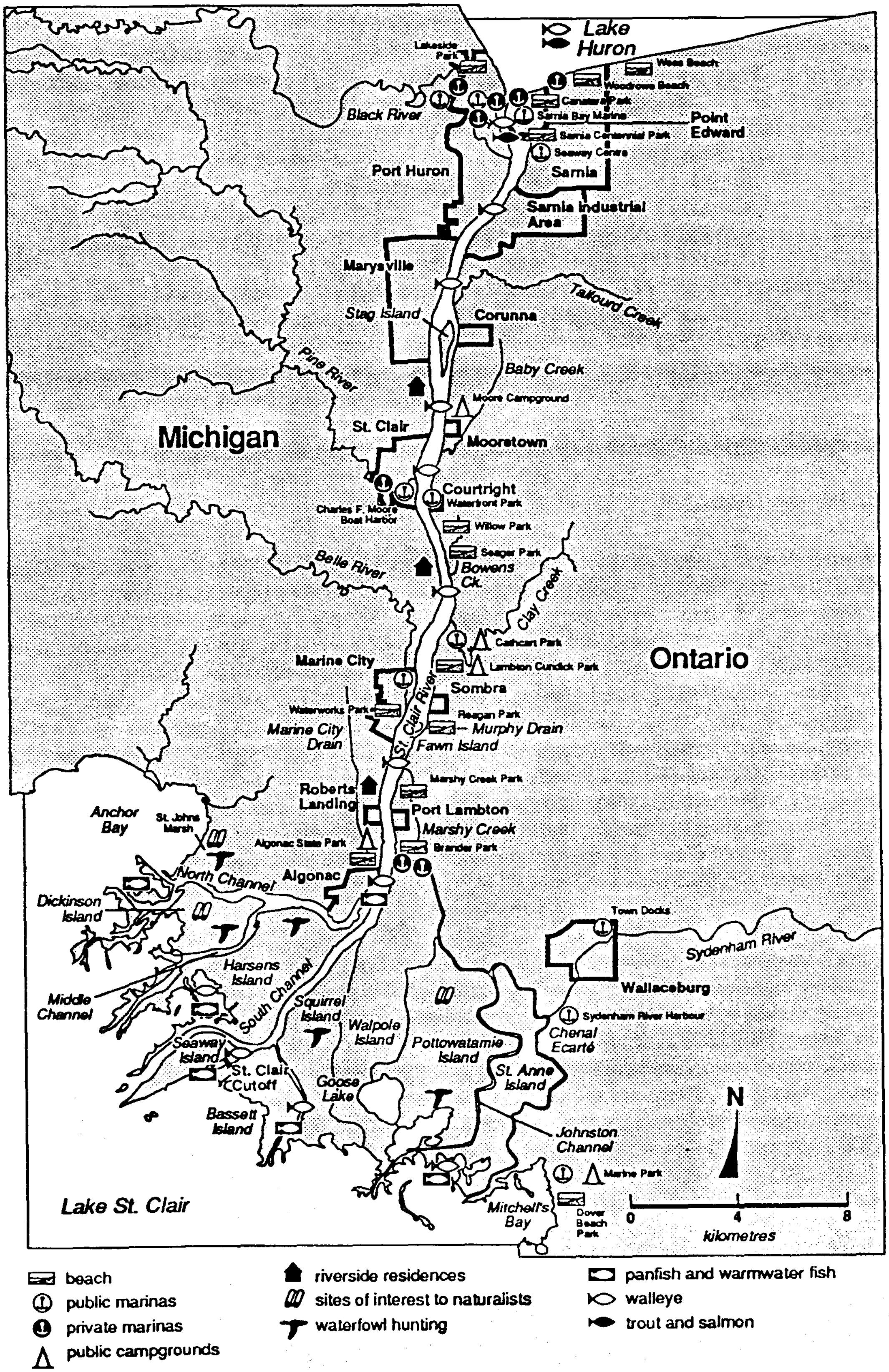
A relatively small portion of the study area is forested. Sixteen percent of the St. Clair River drainage basin in Michigan is classified as forest. Only 7 percent of Lambton County, which borders most of the river in Ontario, is forested. The Ontario Ministry of Natural Resources (OMNR) District Land Use Guidelines for Chatham prepared in 1983 identified Sarnia Township (the area east of Sarnia and Point Edward), Moore Township (located below Sarnia and extending halfway down the length of the St. Clair River), and the Walpole Island Reserve, as 10 to 20 percent forest-covered. Much of the higher pre-delta areas within the delta islands are forested. Five to ten percent of Sombra Township, located along the southern half of the

Figure 5.8

St. Clair River Remedial Action Plan

Recreational uses along the St. Clair River in Ontario and Michigan

(Acres International Inc. 1990)



river, is forest covered. Most of the forested areas are small woodlots. There are no crown forests on the Ontario side of the river.

5.7.7.2 Wetlands

Wetland habitats include large areas of cattail marshes and open water communities which were described in Section 5.6.2.4. There are approximately 550 ha (1,360 acres) of coastal wetlands on the St. Clair River and another 13,230 ha (32,700 acres) in the St. Clair Flats and Lake St. Clair (Edsall et al. 1988a). While some of these wetlands are outside of the AOC, a large portion of them are not (Figure 5.9). Of the 32 coastal wetlands in the overall system (Figure 5.9), eight are on the river and seven are within the delta. Those within the delta are typically much larger. Due to the dramatic water level fluctuations that occur on the Great Lakes, the size, shape and complexity of wetlands can change significantly from year to year. Thus, the extent of mapped wetlands depends somewhat on water levels at the time of mapping.

The loss of wetlands in the AOC is a major concern as it affects habitat availablilty for fish, waterfowl and other wildlife (Section 5.8.3). Wetlands also serve to filter contaminants from water and sediments, regulate the storage and runoff of surface water and protect shorelines from the direct impact of waves. The particular importance of the delta wetlands is underscored by their identification for long term management under the North American Waterfowl Management Plan. Wetland loss is due primarily to historical impacts from agricultural developments, industrial and urban developments, and navigation related activities. As a result, impacts to fish and wildlife habitat have occurred. These are discussed more fully in Chapter 6.

5.7.8 Waste Disposal

A total of 21 industrial and two municipal waste sites and landfills occur in Ontario within close proximity to the St. Clair River. The majority of the industrial waste disposal and landfill sites are located near the head of the river where groundwater seepage rates tend to be highest. There are seven sites of environmental contamination in St. Clair County on the Michigan side of the river that are listed on the Priority List for EVALUATION AND INTERIM RESPONSE under Act 307 (described in Chapter 4). Six of these are within 4.8 km (3 mi) of the St. Clair River, and the seventh site is about 17.7 km (11 mi) from the river. There are no "307 Sites" in St. Clair County where sufficient evidence has been obtained to allow final clean up actions, and no unranked enforcement sites. Unranked enforcement sites are those for which public funding is not anticipated due to litigation, where litigation or settlement with the responsible party is imminent, or a settlement has been achieved. There are no "307 Sites" in St. Clair County proposed for delisting. No sites of contamination have been listed, or proposed for listing on the National Priorities List (Superfund). The "307 Sites" and the Ontario waste sites which are located within close proximity to the river are mapped and discussed in Chapter 8 as potential nonpoint sources of contaminants to the St. Clair River.

There are a large number of deep well injection sites on both sides of the St. Clair River. The U.S. EPA Underground Injection Control program regulates 5 classes of injection wells. A total of 72 injection wells, representing 4 classes, are rule authorized or permitted by the U.S. EPA on the Michigan side of the St. Clair River (UGLCCS 1988, pp. 277). Sixty three of these are in operation, two are temporarily abandoned, and seven are permanently plugged and abandoned. Several are associated with natural gas and petroleum production. There are no injection wells where hazardous waste is injected into or above underground sources of drinking water. Injection wells in St. Clair County are discussed in more detail in UGLCCS 1988, pp. 275-279.

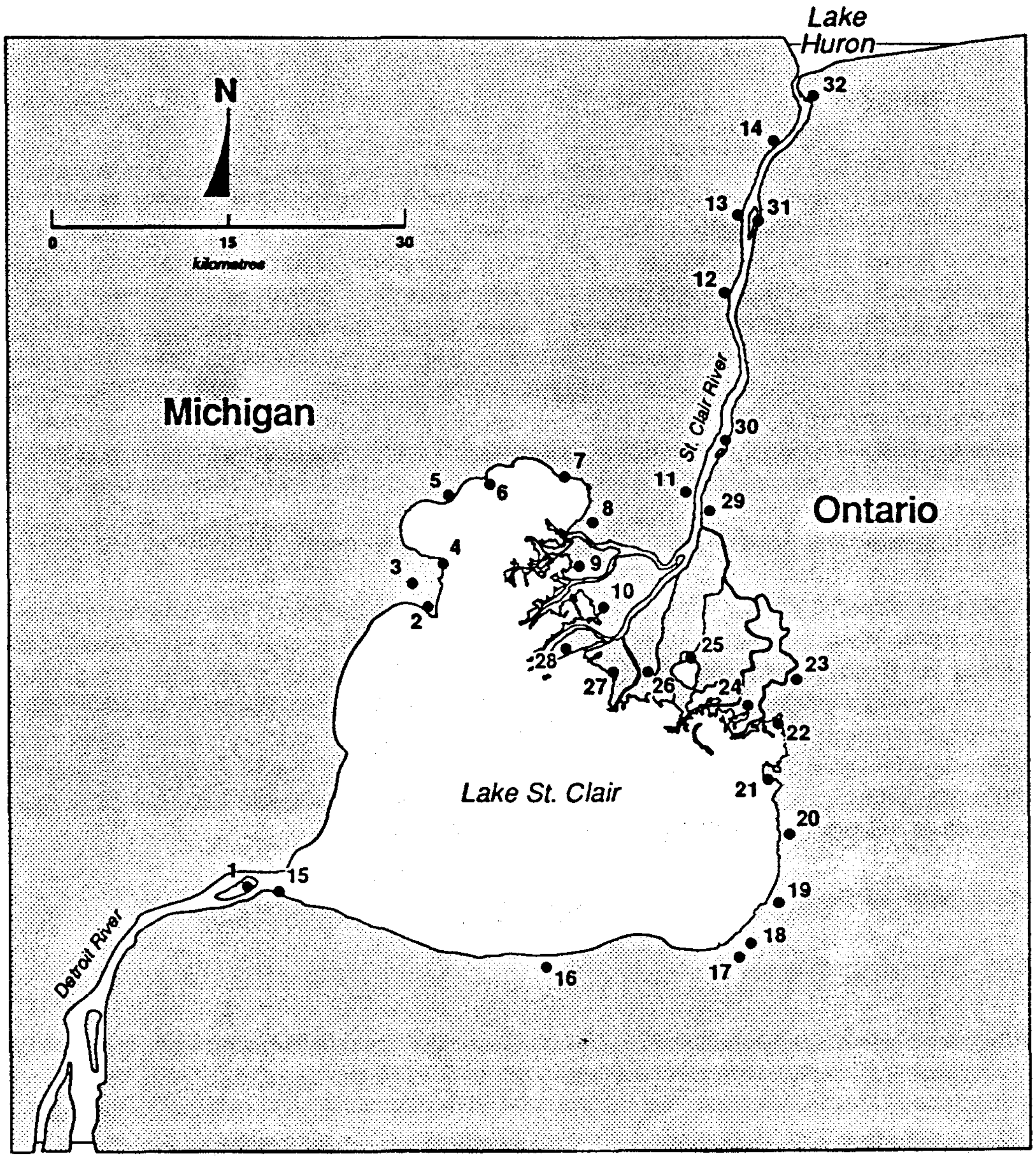
In Ontario, deep injection wells were used to dispose of industrial wastes, cavern brines and oil field brines between 1958 and 1972; there are 35 such wells in Lambton County. A total of 7.5 x 10^6 m^3 of industrial wastes were injected into the Detroit River Geologic Formation during this period (UGLCCS 1988, p. 279). Deep injection wells are still used for the disposal of cavern brine and oil field brines. Of the 35 deep

Figure 5.9

St. Clair River Remedial Action Plan

Location of coastal wetlands of the St. Clair River - Lake St. Clair ecosystem

(Herdendorf et al. 1986)



Michigan

Wayne County

1 Belle Isle

Macomb County

2 Black Creek
3 Clinton River Estuary
4 Belvidere Bay
5 Salt River Estuary

St. Clair County

6 Marsac Point
7 Swan Creek Estuary
8 St. John's Marsh

St. Clair County

9 Dickinson Island
10 Harsens Island
11 Belle River Estuary
12 Pine River Estuary
13 Marysville
14 Port Huron

Ontario

Kent County

18 Bradley Marsh
19 Big Point Marsh
20 Tacky Marsh
21 Mitchell Point Marsh (Moon Island Marsh)
22 Mitchell Bay (Pintail and Mud Creek marshes)
23 Wallaceburg (Bear Creek and Pigeon marshes)

Essex County

15 Peach Island
16 Ruscom River
17 Thames River Estuary

Lambton County

24 St. Anne Island
25 Walpole Island
26 Squirrel Island
27 Bassett Island
28 Seaway Island
29 Port Lambton
30 Fawn Island
31 Stag Island
32 Sarnia

injection wells, approximately 20 active and inactive wells are utilized for these purposes. Underground injection wells are mapped and discussed in Chapter 8 as potential nonpoint sources of contaminants to the river.

5.8 WATER RESOURCE USES

5.8.1 Shipping

The St. Clair River is part of the Great Lakes/St. Lawrence waterway, which is the busiest inland waterway in the world, directly serving eight states and two provinces. The principal cargoes carried up-river from the lower Great Lakes or ocean ports are coal, lignite and iron ore. Iron ore, limestone and grain are the main ommodities carried down-river (Edsall et al. 1988a). Today, after many years of variable shipping traffic, tonnages are much lower than in the 1970s. In 1983, more than 45 million tonnes (40.8 million tons) (Edsall et al. 1988a) which originated in Lake Superior were shipped through the St. Clair River. As noted earlier, industries which rely on the water transport of goods and raw materials were historically attracted to the shores of the river. The main commodities off-loaded at ports along the St. Clair River are limestone at Port Huron and coal at St. Clair and Courtright, for burning at thermal generating stations at these locations (Edsall et al. 1988a). The principal commodities loaded are soybeans (Port Huron and Sarnia), wheat (Sarnia) and petrochemicals (Sarnia) (Acres International Limited 1990). The harbour at Sarnia includes a substantial commercial waterfront, including 320 m (1,050 ft) of dockage for freighters; across the river, the Port Huron Seaway Terminal has 400 m (1,300 ft) of water frontage.

A minimum depth of 8.2 m (27 ft) is required for shipping on the river; this requires periodic dredging of sediments in the lower channels. Dredge spoils from the Canadian channels that exceed the Ontario Ministry of the Environment's (OMOE) open water dredged material disposal guidelines (UGLCCS 1988, p.40) are placed in a confined disposal site on Seaway Island (the Southeast Bend Cutoff Site). Otherwise they are disposed in open waters. A few hundred cubic metres of sediment are dredged from the U.S. channels every few years; these are placed in the Dickinson Island Confined Disposal Facility. Periodic shoal removal on the Michigan side of the river's upper reaches produces a few hundred cubic metres of dredge spoils which are disposed of in the open waters of Lake Huron.

5.8.2 Water Supply

5.8.2.1 Drinking Water

Drinking water needs for approximately 103,000 Canadians and 80,000 Americans are provided by three filtration plants in Ontario, with a total design flow of 205,000 m^3/day (53.3 X 10^6 U.S. gal/day), and seven water filtration plants in Michigan, having a total design flow of 202,000 m^3/day (52.5 X 10^6 U.S. gal/day). If all plants were working at capacity, their daily intake would be equivalent to approximately 0.09 percent of the river's average daily flow. Table 5.10 summarizes the flows and populations served by each of the filtration plants. The Lambton County water supply system, which serves the City of Sarnia as well as the communities of Point Edward and Sombra and Sarnia and Moore Townships, treats water from Lake Huron as its water enters the St. Clair River. The Wallaceburg filtration plant takes its water from Chenal Ecarte.

5.8.2.2 Industrial Intakes

Several industries along the St. Clair River use river water in plant process operations. The largest use is for once-through, no-contact cooling, especially by the thermal generating stations located along the river. These facilities use approximately 88 X 10^6/m^3/day (22,880 X 10^6 U.S. gal/day), which amounts to about 20 percent of the river's average daily flow.

Table 5.10 Water treatment plants taking their water from the St. Clair River. (After Acres International Ltd. 1990)

Water Treatment Plant	Design Flow (1,000 m^3/day)	Population Served
Michigan		
Port Huron	114	47,281
Marysville	56.8	7,745
St. Clair	11.4	5,205
East China Township	3.8	3,222
Marine City	7.6	5,414
Algonac	7.6	10,962
Old Club (seasonal use)	1.1	250
Total	202.3	80,079
Ontario		
Walpole Island	2.5	1,900-2,100
Wallaceburg	13.5	11,300
Lambton County (Sarnia)	189	87,865
Total	205.0	101,065-101,265

5.8.3 Fish and Wildlife Habitat

5.8.3.1 Fish Species and Habitat

The St. Clair River – Lake St. Clair system provides valuable fish habitat. At least 91 species have been recorded as residents or migrants in the river and its delta. Griffiths et al. (1991) summarized five recent studies and reported a total of 83 sport and forage species, 17 of which are rare, for the St. Clair River. Leslie and Timmins (1990a) collected nine taxa as larvae and four others as juveniles in the St. Clair River during 1986. Connecting waters such as agricultural drainage ditches contributed more to species diversity and biomass than did the St. Clair River (Leslie and Timmins 1990b). Leslie and Timmins (1990c) identified an additional eight species to that identified by Griffiths et al. (1991) based on recent work in the St. Clair Delta. Appendix 5.5 provides a complete list of fish species known to occur in the St. Clair River. The wetland areas associated with the delta are particularly important as at least 48 species of fish are known or presumed to utilize the wetlands of the river (UGLCCS 1988).

The river supports a diverse fish fauna with the common species being alewife, gizzard shad, emerald shiner, spottail shiner, white sucker, smelt, rainbow smelt, walleye, muskellunge, rainbow trout, lake sturgeon, coho and chinook salmon, smallmouth bass, channel catfish, yellow perch, log perch, rock bass and freshwater drum (Edwards et al. 1989, Griffiths et al. 1991, Limno-Tech 1985). This diversity results from the availability of spawning and nursery habitats (in the main river, its tributaries and the delta), the presence of food and shelter for juveniles and adults and the migration of fish between lakes Huron, St. Clair and Erie (Edwards et al. 1989, Griffiths et al. 1991). Four species, including sea lamprey and lake herring, were noted by Griffiths et al. (1991) as being represented by a few larval individuals, while 13 others, including lake sturgeon and lake trout, were only represented by one or two juvenile or adult individuals.

Species which were important historically include large runs of lake trout, lake whitefish and lake herring which entered the St. Clair River from lakes Erie and Huron to spawn (Goodyear et al. 1982). Each of these populations disappeared around the turn of the century, probably as a result of overfishing and habitat alterations. No lake whitefish and only a few larval lake herring and juvenile lake trout were collected in recent studies described by Griffiths et al. (1991). Fisheries managers suspect the larval lake herring and juvenile lake trout result from post spawning drift into the river from southern Lake Huron as there is no strong evidence suggesting spawning of either of these species within the river.

The system currently provides spawning and nursery habitat for at least 46 species (Edsall et al. 1988a). The major spawning areas are shown in Figure 5.10 and Table 5.11 lists the common species which are known to spawn in the River and in Lake St. Clair. According to Edsall et al. (1988a), the prime spawning and nursery habitat in the St. Clair River includes shoals, shallow areas around islands, and river shoulders, mainly because water velocities are lower in these areas than in deeper areas of the main channel, however, virtually all of the river provides some degree of fish habitat. At these sites, substrate diversity is high, encompassing rock, gravel, and various mixtures of sands, silts, clays and organics, with colonization by submergent and emergent plants in some areas. Spawning also occurs in the deeper sections of the main channel where the substrate is hard, channel edges have been bulkheaded, water velocities are high, and vascular aquatics are absent. In Lake St. Clair, spawning is confined to nearshore waters and embayments where surficial sediments are softer than along the open shoreline of the lake, where submergent and emergent plants are common, and where wave-generated turbulence is generally low. Collectively, the St. Clair River – Lake St. Chair waterway provides a wide array of habitats needed to satisfy spawning and early life history conditions described in the literature for the large variety of species inhabitating the system (Scott and Crossman 1973 and Goodyear et al. 1982).

The coldwater fish community is largely composed of exotic species (rainbow and brown trout, chinook and coho salmon and rainbow smelt) which have filled the niche left absent by native species (lake trout, lake whitefish and lake herring) (Griffiths et al. 1991) which are thought to have used the river as a migratory route. Rainbow smelt is a seasonally abundant forage fish which spawns throughout the river. The coldwater fish use the river for spawning, feeding and shelter and as a migration corridor between lakes. They support a small but important recreational fishery (Edsall et al. 1988a).

Important members of the coolwater fish community are lake sturgeon, northern pike, muskellunge, walleye and yellow perch. In contrast to coldwater species, coolwater species are present in the river throughout the year (Haas et al. 1985).

Yellow perch and walleye support a large component of the recreational fishery (Haas et al. 1983). Yellow perch utilize the river for spawning, feeding and shelter. They usually occupy shallow waters, feed on benthic invertebrates and small fish and, in turn, are prey for walleye, northern pike and bass. Yellow perch spawn along the western shoreline of Lake St. Clair, in Anchor Bay, in the St. Clair Flats, at several shallow water locations in the St. Clair River, and in the Black River; nursery areas are ubiquitous throughout the waterway.

Northern pike spawn along the shoreline of Lake St. Clair from the mouth of the Clinton River into the St. Clair Flats, and along the western and southern shorelines to about the mouth of the Thames River. Embayments of the flats provide important nursery grounds. Presently, there may only be a single major spawning area for muskellunge, which is in Anchor Bay about 1.6 km (1 mi) east of the Selfridge Air National Guard Base (Haas, 1978). Marshes of the St. Clair Flats are the only recorded nursery area for this species. Both the northern pike and muskellunge move throughout the river, feeding mainly on fish although they will also eat crayfish, frogs, mice, muskrats and waterfowl.

Walleye feed primarily on fish whereas the rare, long-lived sturgeon prefers an assortment of benthic organisms. Both species frequent the deeper channels throughout the river. Sections of the Thames River, a

Figure 5.10

St. Clair River Remedial Action Plan

Major fish spawning areas in the St. Clair River Area of Concern

(Organ et al. 1978, Goodyear et al. 1982 and Edsall et al. 1988a)

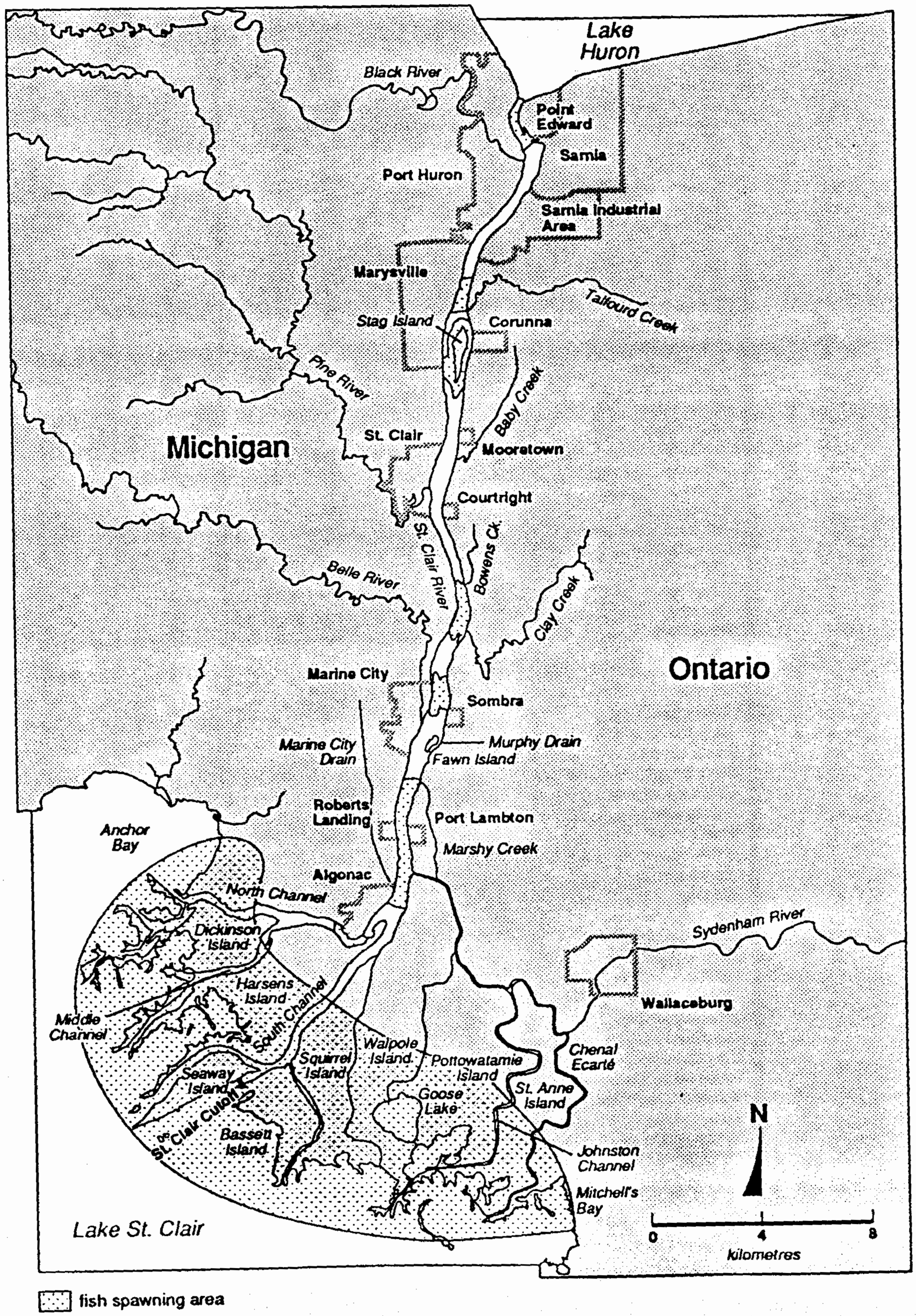


Table 5.11 Fish which spawn in the St. Clair system (Goodyear et al. 1982).

Species	St. Clair River	Lake St. Clair
Lake sturgeon	+	+
Longnose gar		+
Bowfin		+
Alewife	+	+
Gizzard shad	+	+
Mooneye		+
Lake herring	+	+
Lake whitefish	+	+
Rainbow trout	+	+
Lake trout	+	
Rainbow smelt	+	
Northern pike		+
Muskellunge	+	+
Goldfish		+
Carp	+	+
Silver chub	+	
Golden shiner		+
Emerald shiner	+	+
Common shiner		+
Spottail shiner		+
Spotfin shiner		+
Mimic shiner	+	+
Sand shiner	+	+
Blackchin shiner	+	+
Bluntnose minnow		+
Fathead minnow		+
White sucker	+	
Northern hog sucker	+	
Brown bullhead	+	+
Channel catfish		+
Trout-perch	+	
Burbot	+	
White bass	+	+
Rock bass	+	+
Pumpkinseed		+
Bluegill		+
Smallmouth bass	+	+
Largemouth bass		+
White crappie		+
Black crappie		+
Greenside darter		+
Johnny darter	+	+
Iowa darter	+	+
Yellow perch	+	+
Logperch	+	
Walleye	+	+
Freshwater drum	+	
Mottled sculpin	+	
Slimy sculpin	+	
Fourhorn sculpin	+	
Banded killifish	+	+
Brook silversides	+	+
Bluntnose minnow	+	+
Central mudminow	+	+
Brook stickleback	+	+
Shorthead redhorse	+	+
Black bullhead	+	+
Yellow bullhead	+	+

Note: The sea lamprey also spawns in the St. Clair River and Lake St. Clair.

tributary to Lake St. Clair, is considered to be the major spawning sites for walleye in the St. Clair River (Haas et al. 1983). Walleye have also historically spawned in Anchor Bay of Lake St. Clair, along the south shore of the lake, in the Clinton and Sydenham Rivers, in the St. Clair Flats, in several areas of the St. Clair River, and related tributaries. Stocks which were depressed in the early to mid-1900s, have rebounded over the past 20 years, and major spawning runs now occur, with most of the spawning likely occurring in the Thames River (Haas et al. 1985). Thus, in addition to providing habitat for a resident population of walleye, the St. Clair River provides an important migration corridor which annually sees a significant movement of walleye travelling through the river to reach important spawning sites (Ferguson and Derksen 1971). The river is believed to be an important spawning area for lake sturgeon (Goodyear et al. 1982) which include the lower St. Clair River near Marine City and Port Lambton, the North Channel, the head of the river, and/or possibly lower Lake Huron (Hatcher and Nester 1983); however the marshlands of the St. Clair Flats are the only known nursery area for this species in the St. Clair River – Lake St. Clair system.

Good spawning and nursery habitat exists throughout the St. Clair River – Lake St. Clair System for a number of common native warmwater species including longnose gar, bowfin, smallmouth bass, largemouth bass and white bass, channel catfish, suckers and several species of minnows and sunfishes. The suckers, catfishes, basses, sunfishes and freshwater drum are residents of the river throughout the year, migrating only small distances (Griffiths et al. 1991). Freshwater drum and the sunfishes, particularly rock bass, are important components of the recreational fishery (Haas et al. 1983). The white perch, a recent exotic species, will probably contribute to the fishery in the future.

Alewives, rainbow smelt and common carp are amongst the most abundant introduced species in the St. Clair system, with all three species spawning in the St. Clair River and its tributaries. Also, white perch spawn in the AOC; in 1983-1984, a few larvae were captured in the river, and young-of-the-year of this species were among the most abundant fish captured by mid-water trawling in the lake between 1980 and 1985.

Tow net catches of fish larvae in the St. Clair - Detroit System in 1977-78 and 1983-84 showed that the St. Clair River is a nursery area for at least 26 species (Hatcher and Nester 1982, Muth et al. 1986). Average density and relative abundance data indicated that alewife, rainbow smelt, log perch, emerald shiner and gizzard shad dominated catches of larvae from the St. Clair River. The average density of all larvae combined was 206 per 1,000 m^3 for the river during the study period (Muth et al. 1986).

As judged by trap net catch per unit effort from a study by Hass et al. (1985), a number of habitat associations can be made for the St. Clair River. Longnose gar, northern pike, common carp, yellow perch, freshwater drum and channel catfish seemed to prefer the lower portion of the river where maacrophytes predominated. Alewife declined steadily from the upper St. Clair River downstream, probably reflecting the influence of Lake Huron where the species is abundant. Overall, the catch per unit effort was higher in the downstream section of the river than in the upstream section. The influence of the extensive macrophyte cover in the downstream section is thought to be a major factor in this difference (Edwards et al. 1989). This serves to highlight the value of, and the importance in protecting, maintaining and (where possible) enhancing, the remaining macrophytes and wetlands in the AOC.

5.8.3.2 Wildlife Habitat

The wildlife of the St. Clair River basin is very diverse with over 60 species of mammals, 25 species of reptiles, 20 species of amphibians and over 250 species of birds (Limno-Tech 1985). The St. Clair River Delta is particularly significant as wildlife habitat. The marshes of the delta serve as nesting, feeding and staging areas for a rich variety of migratory waterfowl (Limno-Tech 1985). Bird species common to the St. Clair River and Lake St. Clair area are listed in Appendix 5.6; Appendix 5.7 lists the significant breeding birds of the Walpole Island Reserve; Appendix 5.8 lists reptiles and amphibians; Appendix 5.9 lists mammals of the Walpole Island Indian Reserve; and Appendix 5.10 lists significant butterfly species of Walpole Island.

Birds

The St. Clair system, with its extensive wetlands, is internationally recognized as valuable habitat for ducks, geese and swans. In fact, the wetlands and associated open-waters of Lake St. Clair may be the most important wetland system in the Great Lakes region, with the possible exception of Long Point in Lake Erie (Dennis et al. 1984). Wetlands within the St. Clair Delta area are considered as an important focus in the North American Waterfowl Management Plan recently signed by the U.S., Canada and Mexico. A species list is provided in Appendix 5.6. The system lies within both the Atlantic and Mississippi flyways which form major migration coridors for dabbling and diving ducks (Figure 5.11), and provides important staging and rafting waters to the tundra swan, canvasbacks, buffleheads, ruddy ducks, Canada geese, mallards, black ducks, redhead ducks, oldsquaws, scoters, goldeneyes, wigeons and greater and lesser scaups (Martz, MDNR, pers. com., McCullough 1985, Edsall et al. 1988a). Other species, including pintail, wood duck, northern shoveller, hooded merganser, red-breasted merganser, snow goose and mute swan, have also been seen. The area also serves as a nesting ground for several species of waterfowl, including Canada geese, mallards, blue-winged teal, black ducks, redhead ducks and wood ducks, where nesting boxes are available. The largest nesting population of redhead ducks east of the prairies occurs on Walpole Island (G. McCullough, Canadian Wildlife Service, pers. com.).

In September, resident waterfowl are joined by migrating birds from more northerly breeding grounds. Major concentration areas extend from the lower St. Clair River to the middle of Lake St. Clair. In October, or with the beginning of cold weather, when resident and migrating waterfowl begin to move southward, the diked and managed marshes and the coastal wetlands and shallow waters of Lake St. Clair provide critical resting and feeding habitat. The use of the St. Clair River by waterfowl during the winter period can be substantial with up to 4,000 canvasback, redheads and goldeneyes reported (G. Martz, MDNR, pers. com.). In Michigan, during the fall migration, over 25,300 waterfowl have been observed on Harsens Island (Edsall et al. 1988a); an additional 2,300 and 3,000 to 4,000 waterfowl have been seen around Dickinson Island and in St. Johns Marsh, respectively. Dabbling ducks, particularly mallards and black ducks, are the dominant species around Harsens Island and St. Johns Marsh. Diving ducks, especially canvasbacks and common goldeneyes, are most abundant around Dickinson Island. In Ontario, Canadian Wildlife Service (CWS) surveys in the winters of 1983 and 1984 indicated peak numbers of approximately 9,000 ducks of various species, the most common being the canvasback, redhead, golden eye and mergansers. A peak of of 19,000 ducks was recorded during the winter of 1982 (G. McCullough, pers. com.). Spring migration from the southern overwintering grounds begins in mid-March with the onset of ice break-up, and generally follows in the opposite direction the route of the fall migration; by late April or early May, the main flights have passed through Michigan.

Studies of the marsh lands associated with the Ontario portion of Lake St. Clair conducted by CWS between 1968 and 1982 showed these areas to be used extensively by a wide assortment of waterfowl during spring and autumn migrations. Dennis and North (1984) estimated peak waterfowl numbers at approximately 60,000 birds in the spring and nearly 150,000 in the autumn. In a survey of migrating waterfowl use of the Ontario shorelines of the Great Lakes of southern Ontario. The Lake St. Clair marshes of which the delta forms a major component, ranked as the second most important staging area in southern Ontario (Dennis et al. 1984).

Important waterbirds include coots, grebes (2 species), rails (5 species) and moorhens. Up to 360 American coots have been seen in St. Johns Marsh during the fall migration (Edsall et al. 1988a); these have also been observed on Dickinson Island (Herdendorf et al. 1988). The horned grebe has been seen on Harsens Island and the pied-billed grebe has been observed in St. Johns Marsh. The king rail and Virginia rail have been observed in St. Johns Marsh and Harsens Island, as has the common moorhen. The king rail is listed as rare by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, Burnett et al. 1989) and is known to nest on portions of the delta (A. Woodliffe, OMNR, pers. com.). The king rail is listed as endangered by the Michigan Department of Natural Resources (MDNR) (G. Martz, MDNR, pers. com.).

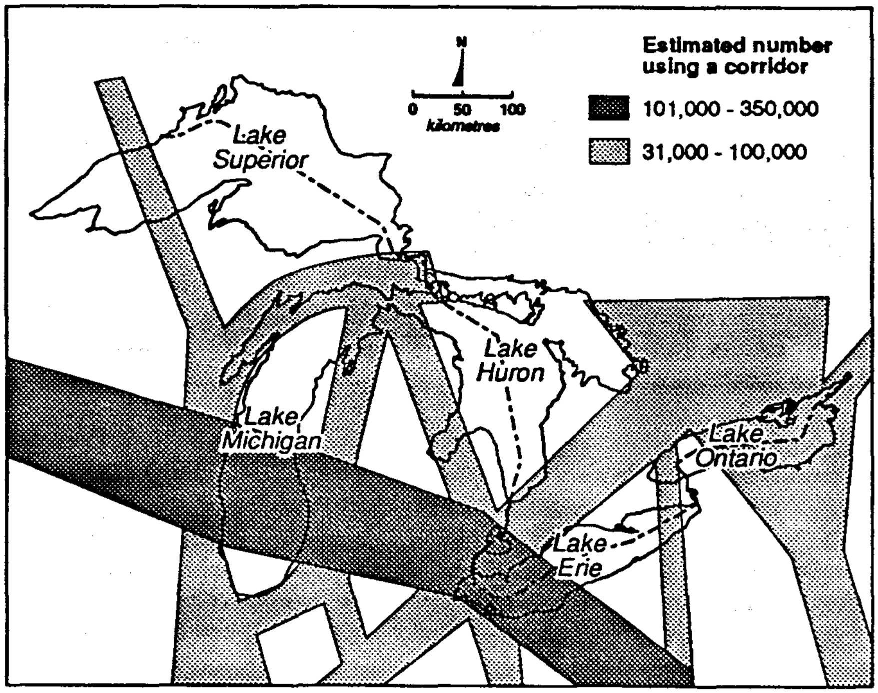
Figure 5.11

St. Clair River Remedial Action Plan

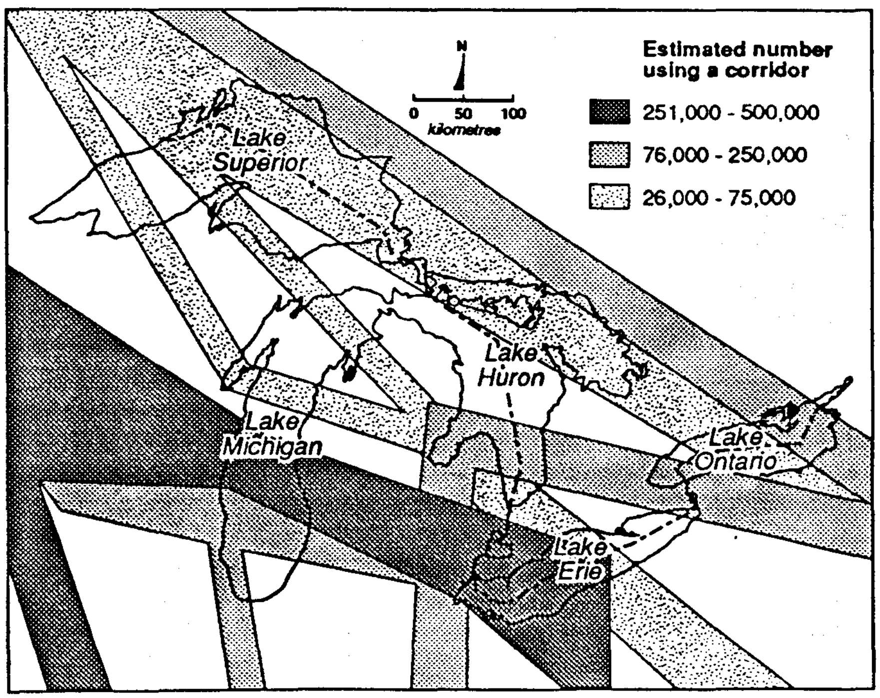
Fall migrations of dabbling ducks and diving ducks

(Edsall et al. 1988a)

dabbling ducks



diving ducks



A number of wading birds are found within this area, including herons (7 species), bitterns and egrets. The green-backed heron and the black-crowned night-heron have both been observed in St. Johns Marsh (Herdendorf et al. 1986). The great blue heron can be found throughout the St. Clair Delta. An active heron rookery is located on Dickenson Island (G. Martz, MDNR, pers. com.). American and least bitterns and great and cattle egrets have all been seen within St. Johns Marsh. The least bittern and great egret are known to nest in the wetlands of the delta (A. Woodliffe, OMNR, pers. com.). The least bittern has been designated as rare within the Great Lakes by COSEWIC (Burnett et al. 1989).

Shorebirds which frequent this system include several species of plovers (3 species) and sandpipers (12 species) including the common snipe and American woodcock (Herdendorf et al. 1986).

Gulls and terns are also abundant within the AOC (11 species). The common tern (listed as threatened by MDNR) and the the Forsters tern (listed as a species of special concern) have been observed throughout the Michigan portion of the St. Clair Delta (G. Martz, MDNR, pers. com.). The Forster's tern is a common nester in the channels of Bassett and Squirrel Islands (C. Weseloh, CWS, pers. com.). The herring gull and common tern are seen throughout the delta. The ring-billed gull has been seen in St. Johns Marsh and Forster's tern, the black tern and the little gull have all nested in the marsh during the 1980s. The Caspian tern, which has been identified in this area, is listed as rare by COSEWIC (Burnett et al. 1989).

Raptors including the red-tailed hawk, sparrow hawk and great horned owl, are frequently seen in the AOC. Ospreys and bald eagles are seen in small numbers during migration. Other raptors which have been sighted in the vicinity of the delta include Cooper's and rough-legged hawks and northern harriers (Herdendorf et al. 1986); Cooper's hawk is listed as rare by COSEWIC (Burnett et al. 1989) and is considered a species of special concern by MDNR (G. Martz, MDNR, pers. com.). The American kestrel and golden eagle have also been reported for this area. Bald eagles are sighted annually in early winter on the Canadian portion of the delta and river (A. Woodliffe, OMNR, pers. com.). These birds are listed as threatened by MDNR (G. Martz, MDNR, pers. com.). Both the bald eagle and golden eagle are listed as endangered species in Ontario (J. Brisbane, OMNR, pers.com.).

Other prominent birds found within the St. Clair Delta are the belted kingfisher, the sedge and marsh wrens, the eastern meadowlark and the yellow-headed and red-winged blackbirds. The prothonotary warbler and the eastern bluebird, both of which are listed as rare by COSEWIC (Burnett et al. 1989), commonly use the area (A. Woodliffe, OMNR, pers. com.). A list of 28 significant breeding birds of Walpole Island Indian Reserve was compiled by Woodliffe (1988, Appendix 5.7). This list provides further evidence that the St. Clair Delta supports a diverse and significant bird community.

Amphibians and Reptiles

The relatively undisturbed wetlands of the St. Clair Delta probably support a present day amphibian and reptile community similar to that of pre-settlement times (Herdendorf et al. 1986). Some of the species which occur in habitats associated with the wetlands of the delta include the mudpuppy, red-spotted newt, blue spotted salamander, four-toed salamander, red-backed salamander, gray treefrog, northern spring peeper, western chorus frog, bullfrog, wood frog, american toad, eastern fox snake, eastern massassauga rattlesnake, northern water snake, northern red-bellied snake, northern brown snake, eastern garter snake, black rat snake, blue racer, snapping turtle, Blanding's turtle and midland painted turtle (Herdendorf et al. 1986). Amphibian and reptile species are listed in Appendix 5.8.

The eastern fox snake, a wetland-dependant species, is listed as threatened by the state of Michigan (Herdendorf et al. 1986). So is the black rat snake, which is thought to occur in the drier margins of the wetlands. The eastern massassauga rattlesnake is a candidate for U.S. Federal listing on the threatened/endangered list, and is considered rare (rank S3) in Ontario by the Nature Conservancy of Canada (Sheila McKay-Kuja, Ontario Conservation Data Centre, Toronto, pers. com., August 1990). The eastern spiny softshell turtle, spotted turtle, and four-toed salamander are considered rare in Michigan and Ontario.

Mammals

The wetlands of the delta are important habitat for mammals (Appendix 5.9) including muskrat, mink, Virginia opossum, striped skunk, red fox, eastern cottontail, European hare, woodchuck, fox squirrel, gray squirrel, red fox, raccoon, weasel, badger and white tailed deer (Herdendorf et al. 1986). The gray fox and southern flying squirrel are considered rare within the Great Lakes region by COSEWIC (Burnett et al. 1989). Muskrats are very abundant in the wetlands and are important as both a furbearing resource and as a means of managing wetlands. For example, muskrat increases can create more open-water areas within bulrush and cattail stands (Edsall et al. 1988a); thereby creating more opportunities for nesting waterfowl and wading birds.

5.8.4 Commercial Fishing

A commercial fishery was first established in the St. Clair – Detroit River system in the early 1800s for lake whitefish, lake herring, walleye and yellow perch (Edsall et al. 1988a). The main centres in Michigan were at Robert's Landing, Marine City, St. Clair and Algonac. By the late 1800s, lake sturgeon, lake herring, lake whitefish, smallmouth bass, yellow perch and walleye (Table 5.12), were abundant in the catch throughout the St. Clair, however, the fishery in the St. Clair River was small (Edsall et al. 1988a). By the turn of the century, carp were added and some native species became less abundant. For example, smallmouth bass, lake herring and lake whitefish were no longer important components of the catch by 1910, 1930 and 1950 respectively, while lake sturgeon, yellow perch and walleye continued to contribute significantly through to the 1960s. In Ontario, channel catfish, bullheads, white sucker and northern pike have always made up a small portion of the fishery. The observed early declines in the catch of some of the more desirable species were probably due to overfishing (Haas and Bryant, 1978), but the catch records also reflect the permanent closure of Michigan's commercial fishery in 1909 to all species except carp, in response to increasing pressure from recreational fisherman (Edsall et al. 1988a). For the same reason, the smallmouth bass commercial fishery was closed in Ontario. A commercial fishery continued to operate in the Ontario portion of Lake St. Clair until 1970 when high mercury levels in the lake forced its closure. The fishery was reopened in 1980, after mercury levels had decreased to levels which no longer prevented human consumption. With the re-opening, quotas were established for carp, suckers, catfish, yellow perch, white bass, bullheads, lake sturgeon, northern pike, and rock bass and crappie (Table 5.13). As explained by Edsall et al. (1988a),

> "...the quotas were based on the average annual catches for these species during the last decade before the closure of the commercial fishery, except that there was no allocation for walleyes in the new fishery [see Table 5.13]. However, none of the allotted annual quotas were filled in 1980-1985 and catches for most species that contributed to the earlier fishery were substantially lower in 1980-1985 than in the 1960s. Although the reduced catches of economically valuable species such as lake sturgeon and yellow perch in 1980-1985 may reflect their lowered abundance in the St. Clair system, the reduced catch of carp and other low-value species, which make up the majority of the present fishery, probably reflect market conditions. Thus, the overall decline in catch since 1981 appears to reflect the marginal economics of the fishery (OMNR 1986), and there is speculation that a complete closure of the Ontario commercial fishery is imminent. Seven of the ten commercial fishing licenses issued by the Province of Ontario for Lake St. Clair in the 1980s were bought back by the Province and retired on December 1985 (OMNR 1986)."

Today there is no commercial fishing within the St. Clair River north of Walpole Island. The OMNR's Chatham District Fisheries Management Plan and Chatham District Land Use Guidelines indicate that by

Table 5.12 Commercial fish production in Michigan and Ontario waters of the St. Clair-Detroit River system 1870-1969 (Baldwin et al. 1979).*

	Average Annual Landings (Thousands of kg) by Decade										
Year	Lake Sturgeon	Lake Herring	Lake Whitefish	Northern Pike	Carp	Suckers	Channel Catfish and Bullhead	Small-mouth Bass	Yellow Perch	Walleye	Total of Species
1870-79	50[a]	57[f]	168[g]	6[c]				19[d]		67[e]	417[g]
1880-89	37	191[g]	60	10		139[a]	17[a]	19	98[a]	74	584[g]
1890-99	46	106	38	12		53[f]	10	16	146[a]	239	821
1900-09	22	3	26	16	142[c]	9	21	1[b]	31	135	597
1910-19	15	2[d]	28	21	186		26		54	25	592
1920-29	6		1	15	119		24		44	23	379
1930-39	5		<1[g]	10	148		20		21	18	349
1940-49	3		<1[b]	8	128		41		16	24	328
1950-59	5			6	245	50[f]	29		13	29	430
1960-69	6			10	115	44	35		16	117	427

* Production values for each decade were obtained by dividing the total recorded production for the decade by the number of years in the decade for which production records were available; values based on less than 10 years of recorded production are footnoted as follows:

[a] 1 year — [e] 6 years
[b] 2 years — [f] 8 years
[c] 4 years — [g] 9 years
[d] 5 years

Table 5.13 Commercial fishery quotas and landing for Ontario waters of Lake St. Clair, 1980-85 (OMNR 1986).*

Species	Quota	1980	1981	1982	1983	1984	1985
Bowfin	--	2	3	2	7	6	3
Bullheads	5	1	2	1	1	<1	0
Carp	150	15	58	66	19	28	8
Catfish	33[1]	6	42	32	30	27	20
Freshwater Drum	--	5	14	23	15	2	0
Northern Pike	4	1	2	1	2	1	1
Rock Bass and Crappie	3	<1	1	2	3	1	1
Lake Sturgeon	5	0	0	0	0	0	<1
Suckers	45	5	19	19	23	6	2
White Bass	11	2	9	9	5	3	1
White Perch	--	0	0	<1	1	<1	0
Yellow Perch	14	<1	1	2	4	2	<1
Mixed[2]	--	<1	7	<1	1	1	<1

* Quotas and landings are in thousands of kg.
[1] An additional quota was allocated for 1981-85.
[2] Includes bowfin, freshwater drum, garpike, gizzard shad, suckers, white perch. (When this value is large, it is predominantly freshwater drum and suckers.)

the year 2000, the end of its planning horizon, there will be no commercial fish target allocated to the St. Clair System.

Baitfishing is an important industry on the Ontario side of the St. Clair River, spurred by the popularity of sportfishing. As of 1983, more than 1.3 million baitfish are annually harvested (OMNR, 1983). This yield, approximates the OMNR's target for the AOC.

5.8.5 Sportfishing

Sportfishing has been popular on the St. Clair River since the mid-1800s. Several sportsmen's clubs were established between 1850 and 1873, including the Ste. Anne Club and the Canada Club on the Ontario side of the delta, and the Grande Pointe Club and the Old Club on the Michigan side.

Today the river continues as a popular fishing location. Edwards et al. (1989), using data provided by Hass et al. (1985), provided some important sportfishing related information for the Michigan portion of the river. They indicated that during 1983-84 anglers expended an estimated 1.6 million hours of angling effort in the St. Clair River, and the average overall catch was 0.24 fish per hour. Estimated angler effort was 281 hours per hectare (114 hr/acre). Considering the average annual sport fishing effort on inland lakes is 94.1 hr/ha (38.1 hr/acre) (Colby et al. 1979), the St. Clair River provides a substantial amount of recreation (Edwards et al. 1989).

Using data from the 1983-84 study by Hass et al. (1985), Edwards et al. (1989) estimated that 67 fish, weighing a total of 32 kg were harvested per hectare (28.6 lb/acre) annually in the river. This equated to an angler harvest of 6,471 fish/km (4,012 fish/mi) or 3,046 kg/km (10,833 lbs/mi) of the St. Clair River. Data from this study also provided some insight into the importance of the walleye fishery in the river. The average annual harvest of walley from Michigan waters alone was estimated to be 26.7 kg/ha (23.8 lb/acre) in the river, considerably higher that most other estimates reported in the literature. Colby et al. (1979), who summarized available studies of walleye biology, determined that 'good' walleye waters yield about 5 kg/ha/yr (4.5 lb/acre/yr) to anglers (Edwards et al. 1989).

The high productivity of the St. Clair River and other connecting channels may be partly due to migrations of stocks from the adjacent Great Lakes. Fish tagging studies in the St. Clair and Detroit Rivers during 1983-85 included 43 species of fish (Hass et al. 1985); of these, 13 were recovered in sufficient quantities to enable rough estimates of movement. Average distances moved and rates of travel were highest for walleyes and white bass. Walleye, yellow perch, channel catfish, freshwater drum and white sucker showed a strong tendency to move between the St. Clair and Detroit Rivers and Lakes Huron and Erie (Edwards et al. 1989).

No Ontario based intensive creel surveys have been undertaken on the river, however, some Ontario based records are available for Lake St. Clair. For example, in 1977-1985, ice anglers fished an average of 33,140 angler days and harvested an average of 128,838 walleye, yellow perch and bluegills annually. Over the same period, summer anglers expended an average of 93,225 angler days and harvested an average of 193,382 walleye, yellow perch, smallmouth bass and muskellunge annually. In the Canadian St. Clair Flats, angling activity is regulated by the Walpole Island Indian Band. On the basis of fishing licences issued by the Band for 1989, an estimated 37,700 angler days were spend in Canadian delta waters that year (Acres International Limited 1990). From the OMNR's voluntary angler diary program, it was estimated that a further 43,600 angler days were spent upriver on the Ontario side of the AOC. Using a 1989 OMNR estimator for angler day expenditures, and the total number of angler days of activity, Acres International Limited (1990) determined the value of the Canadian sportfishery to be in the order of $3.2 million (Cdn).

In Michigan, the first creel censuses (Table 5.14), conducted during 1942-1943, revealed that for the St. Clair River - Lake St. Clair - Detroit River system, there were 319,000 angler days of activity, with a harvest of 698,000 fish. Subsequent surveys indicated that the average annual fishing effort and catch respectively, increased to 1,331,000 angler days, and more than 5,000,000 fish in 1966-1967, and to 1,429,000 angler days and 8,381,000 fish in 1970-1977. Although these statistics suggest a significant improvement in the fishery, differences between the three periods must be interpreted with caution. For example, the earlier records did not include the winter fishery, fishing activity on the St. Clair River and Detroit River, or both; furthermore, the estimates obtained from these creel censuses which were conducted by mail are suspected of being somewhat inflated (R. Haas, MDNR, pers. com.). In 1983-1985, an extensive survey of the recreational fishery in Michigan waters of the St. Clair system (Table 5.15) revealed an average annual fishing effort of 690,750 angler days, and an average combined catch by boat, shore and ice anglers of 1,392,000 fish. Yellow perch was the single most abundant species in the catch (37% of the total catch), followed by white bass (34%), walleye (15%), and drum (5%). However, walleye made up the greatest portion of the catch in the St. Clair River and the St. Clair Flats (75% and 58% respectively, of the total catch), while yellow perch dominated the catch in Lake St. Clair (73%). Using data on effort from this study and user spending estimates (in 1989 dollars), the total spending generated by the recreational fishery was determined to be about U.S. $7.6 million (Acres International Limited 1990).

Table 5.14 Creel census estimates of average annual effort and catch for the recreational fishery in Michigan waters of the St. Clair-Detroit River system, 1942-77 (Haas and Bryant 1978).

Period	Number of Angler Days	Total Number of Fish Caught of All Species
1942-42 [1]	319,000	698,000
1966-67 [1,2]	1,331,000	5,074,000
1971-77 [3]	1,499,000	8,381,000

[1] Does not include winter fishing.
[2] Does not include fishing activity on St. Clair and Detroit Rivers, in 1967.
[3] Includes winter fishery and fishing activity on the St. Clair and Detroit Rivers.

Table 5.15 Average annual fishing effort and catch in the Michigan portion of the St. Clair system, 1983-85 (Haas et al. 1985).

Section	Angler Hours	Number of Fish Caught
St. Clair River	552,000	139,000
St. Clair Delta	258,000	55,000
Lake St. Clair	1,953,000	1,198,000
Total	2,763,000	1,392,000

5.8.6 Hunting and Trapping

The opportunities for hunters within the OMNR's Chatham District are listed in Table 5.16. While the majority of deer hunting opportunities are within Lambton County, most areas are relatively far away from the St. Clair River. Small game hunting is distributed amongst small woodlots throughout the district. Estimates of 1983 waterfowl hunting use suggest that 98,600 waterfowl hunting occasions existed in Lambton and Kent Counties; many of these depend on the wetlands of the St. Clair River and St. Clair Flats.

OMNR's management plan provides for a 25 percent increase in waterfowl hunting opportunities by 2000. Between 1973 and 1980, an average of 104,100 pelts were harvested annually; 94 percent were muskrat with the remainder being fox, mink, coyote, beaver, skunk and weasel.

Table 5.16 Management plan for hunting within Chatham District (OMNR, 1983).

Activity	Present Use* (recreation opportunities, number of pelts)	Potential	Target
Big Game Hunting (Deer)	1,480	3,260	2,500
Small Game Hunting	92,500	150,000	120,690
Waterfowl Hunting	98,600	178,000	122,650
Trapping	104,100	93,000	93,000

* Note: The trapping harvest exceeds the potential and target numbers in some instances; this does not necessarily indicate an over-harvest situation. Harvest levels tend to rise and fall based on market conditions and have typically balanced closely with estimated potential numbers.

Hunting opportunities in this part of Michigan are shown in Table 5.17 for small game and for big game (deer). St. Clair County provided only one to two percent of Michigan's hunting activity and harvest. However, duck hunting has long been an important sport with much of the State's waterfowl hunting occurring within the St. Clair River, Lake St. Clair and Detroit River system. During 1971-75, 116,744 waterfowl hunters expended 1,232,526 days of hunting effort, harvesting about 685,000 ducks, geese and coots annually in the State (Table 5.18). Waterfowl hunting effort declined markedly in Michigan and North America, in general, during the late 1970s and early 1980s. By the late 1980s, only 47,630 hunters participated in waterfowl hunting. They expended a maximum of 689,066 days of hunting effort, harvesting 425,568 ducks and geese annually during 1985-89 (Table 5.19). Harvests in St. Clair County (Tables 5.20 and 5.21) are higher than in any other county in Michigan, with an average annual harvest of over 16,000 ducks between 1961-70 (Edsall et al. 1988a) and 27,000 during 1976-85 (Gamble 1989). There may be many others who do not participate because of a lack of quality hunting areas. Prospective hunters, particularly those from metropolitan southeastern Michigan, often apply for reservations at public game areas because of a high success rate and permission to hunt on the few remaining private wetlands is difficult to obtain. The unsatisfied waterfowl hunting demand is evident when one compares the number of applicants at three public game areas within coastal wetlands in southeast Michigan (13,450) to the number of available blinds (3,475). Resource managers have estimated that waterfowl hunting contributes at least U.S. $15.2 million annually to Michigan's economy (in 1977 dollars); an even higher value results (U.S. $15.7 million) when a value-added estimate for meat is factored in. As pointed out by Edsall et al. 1988a:

> "...If data on numbers of hunters and distance travelled were available for each coastal wetland, then the economic importance of waterfowl hunting could be determined and protection priorities established. Further, if the value of the unfulfilled demand for quality waterfowl hunting were included, the total annual value of waterfowl hunting in Michigan could be $30 million or more."

According to Jaworski and Raphael (1978), more than 20,000 muskrats were harvested annually over the 1965-1975 period in St. Clair County and Macomb County.

Table 5.17 Michigan big and small game hunting statistics for the St. Clair River area, 1985 to 1989 (from MDNR, Wildlife Division, Surveys Section data files).

Activity	Average Annual Hunter Trips	Average Annual Harvest
Big Game Hunting (deer):		
St. Clair County	112,692 (1.2%)	1,801 (0.5%)
Macomb County	37,677	387
Michigan Total	9,510,670	336,381
Small Game Hunting[1]		
St. Clair County	139,353 (2.4%)	64,090 (1.9%)
Macomb County	45,631	25,057
Michigan Total	5,923,616	3,312,898

[1] ruffed grouse, woodcock, quail, pheasants, cottontail rabbits, snowshoe hares and squirrels

Table 5.18 Annual waterfowl hunting effort and harvest in Michigan, 1971 to 1975 (Michigan Department of Natural Resources, Biennial Reports).

Year	Number of Hunters*	Number of Hunter Days	Number of Waterfowl Harvested		
			Ducks	Geese	Coots
1971	123,000	1,311,050	593,280	38,000	87,750
1972	109,130	1,120,040	530,960	25,550	34,560
1973	116,310	1,324,930	598,290	38,610	54,260
1974	116,780	1,200,980	615,440	43,090	48,280
1975	118,500	1,205,630	651,860	32,430	32,450
Average	116,744	1,232,526	597,966	35,536	51,460

* Includes waterfowl hunters under the age of 16 not requiring a Federal duck stamp.

Table 5.19 Annual waterfowl hunting effort and harvest in Michigan, 1985 to 1989 (Michigan Department of Natural Resources, Wildlife Division Report No. 3125).

Year	Number of hunters	Number of hunter days	Number of waterfowl harvested		
			Ducks	Geese	Coots
1985	50,440	715,000	363,280	73,380	No Data
1986	50,880	728,380	341,480	78,130	"
1987	45,940	666,260	315,660	103,520	"
1988	42,380	632,640	269,450	122,010	"
1989	48,510	703,050	291,150	169,780	"
Average	47,630	689,066	316,204	109,364	"

Table 5.20 Average annual duck harvest in Michigan, 1961 to 1970 (Jaworski and Raphael 1978).

County	Dabblers	Divers	Total	Percent of Statewide Harvest Made in County
St. Clair	8,475	7,951	16,246	7
Wayne	2,210	7,870	10,080	4
All other coastal counties	49,667	27,632	67,682	28
All inland counties	102,581	44,196	146,777	61
Total	162,933	87,649	240,785	

Table 5.21 Average annual duck harvest in Michigan, 1976 to 1985 (Gamble 1989).

County	Dabblers	Divers	Total	Percent of Statewide Harvest Made in County
St. Clair	21,743	5,481	27,224	9
Macomb	3,413	1,742	8,537	3
Wayne	1,644	2,701	4,345	1
All other counties	205,216	60,875	262,709	87
Total	232,016	70,799	302,815	

5.8.7 Native Consumptive Resource Utilization

Fishing, hunting and trapping are all important to the native people living on the St. Clair River. These activities not only constitute traditional values, but they also provide food and revenue. The percentage of Walpole Island Indian Band households that eat various types of wild meat is provided in Table 5.22. At least half of the households surveyed consume fish, duck, muskrat, deer and miscellaneous wildmeats (which include beaver, bullfrog, turtle, geese, coot and racoon). Fifty-nine percent of ducks consumed are mallards, 20 percent are teals and 17 percent are redheads. Muskrats are the main furbearers harvested by members of the Walpole Island Band. Prior to 1980, more than 100,000 animals were taken annually (Acres International Limited 1990). Each pelt was valued at $6 (Cdn) in 1987. Due to the overal decline in the fur industry, the annual harvest decreased to only 10,000 pelts with a total value of $20,000 (Cdn) in 1989. As well, considerable revenue is generated through the lease of reserve lands to rod and gun clubs. In this regard, there are currently five such leases, covering some 5,000 ha (12,400 acres) (Dean Jacobs, pers. com.). In addition to the revenues generated from these leases, the clubs employ First Nation citizens in their regular maintenance and operation. Fishing and hunting provide additional employment opportunities, as all non-Indians using reserve lands are required to do so under the supervision of an Indian guide. According to Acres International Limited (1990), about 4,800 hunters used the Walpole Island marshes in 1986, providing at least $1.5 million (Cdn) in 1989 dollars for licences, lease fees and revenue from guiding.

5.8.8 Swimming and Recreational Boating

The St. Clair system is readily accessible to four million people in southeastern Michigan and southwestern Ontario, and is one of the most intensively utilized recreational water bodies in North America (Edsall et al. 1988a). As noted earlier, the most popular beaches are located at the head of the river, along the shoreline

Table 5.22 Proportion of household on Walpole Island which consume wild meats (Nin.Da.Waab.Jig. 1986).

Meat	Percent of Households
Fish	86
Duck	79
Muskrat	56
Squirrel/Rabbit	29
Pheasant/Woodcock	24
Deer	64
Miscellaneous	50

of Lake Huron (at Pinery Provincial Park and Lakeside State Park); because of their quality, they provide many of the swimming occasions in the AOC's vicinity.

Pleasure boating is a significant use of the waterway. In this regard, the results of a 1980 survey indicated that boaters annually spent a total of 700,000 days in the St. Clair River and Lake St. Clair (Edsall et al. 1988a), representing an increase of more than 23 percent in comparison with 1977 use. Fishing is the most frequent boating use (53%), with cruising accounting for an additional 35 percent. Five percent of boating is associated with water skiing and the remainder is divided amongst other activities, such as hunting. Total seasonal slip rentals on the Michigan side of the St. Clair River are estimated to be 2,925 units, with demand for new berths equal to 3,000 units. Similar estimates are not available for the Ontario side; however, in 1989, 1,929 rental slips were available (SLEDC 1990).

5.8.9 Naturalist Uses

The lower reaches of the St. Clair River and its delta, provide numerous opportunities to naturalists. One of the main attractions is the number and variety of waterfowl which can be viewed in this area during the spring and fall. The shallow bays and intricate channels of the delta wetlands provide excellent canoeing opportunities. As well, the extensive physical diversity of the delta provides for equally diverse plant communities. In addition to observing successional changes as one moves landwards, there are a variety of localized communities, including abandoned river channels and backshore beachridges. Also, a number of rare and endangered plant species can be seen within the delta; these provide excellent opportunities for viewing, interpretation and education and photography.

5.8.10 Effluent Receiver

5.8.10.1 Point Source

There are a total of 56 point sources in Ontario and Michigan which discharge either directly to the St. Clair River or indirectly via its tributaries. These include thermal electric generating stations; industrial factories representing the organic chemicals, inorganic chemicals, petroleum refining, pulp and paper, and food processing sectors; and municipal wastewater treatment plants and sewage lagoons. Total point source flows from all facilities are approximately 11,800 X 10^3 m^3/day (3,068 X 10^6 U.S. gal/day). This is equivalent to 2.7 percent of the river's average flow. Approximately 80 percent of this discharge is once-through, non-contact cooling water used by thermal generating facilities.

On the Michigan side, there are eleven major point source discharges within the AOC; a listing is provided in Table 5.23. Five municipal Wastewater Treatment Plants (WWTP) discharge directly to the St. Clair River. In 1989, these WWTP discharged a combined average of 66.79 X 10^3 m^3/day (15.36 X 10^6 U.S. gal/day) of treated wastewater. Of the remaining facilities, three are Detroit Edison power plants, two are paper companies and one is a food grade salt processing plant. The power plants discharged a combined average of 6,418 X 10^3 m^3/day (1,669 X 10^6 U.S. gal/day), mostly noncontact cooling water. The three industries, Akzo Salt, E.B. Eddy and James River KVP discharged a combined average of 41.86 X 10^3 m^3/day (10.88 X 10^6 U.S. gal/day) treated process water in 1989. Descriptions of these facilities, their effluent characteristics and National Pollutant Discharge Elimination System (NPDES) permits are provided in Chapter 8.

Ontario Hydro's Lambton Generating Station in Courtright is a two thousand megawatt facility which discharged 3,000 X 10^3 m^3/day (780 X 10^6 U.S. gal/day) of one-through cooling water in 1989 (Table 5.24). The plant also produces wastewater during steam production, which is treated by pH adjustment, settling and filtration. Additionally, runoff from its coal pile is collected and pumped into an ash disposal pond for treatment, before overflowing into a ditch which drains to the St. Clair River.

Of the remaining 1,921 X 10^3 m3/day (499 X 10^6 U.S. gal/day) of effluent discharged by Ontario point sources into the St. Clair River during 1989, 1,881 x 10^3 m^3/day (489 X 10^6 U.S. gal/day), or 97.9 percent, was produced by industry (Table 5.24). The largest portion of this effluent comes from the petroleum refining and petrochemical manufacturing plants located within a 10 km (6.2 mi) strip fronting the St. Clair River. This area, located immediately below Sarnia, is known as the "Chemical Valley".

Several of the petrochemical facilities located in the "Chemical Valley" were constructed during the early 1940s in support of the war effort. The Sarnia area was selected because of its proximity to the St. Clair River, as well as the presence of local underground salt deposits, both pre-requisites for manufacturing chlorinated organic chemicals.

A listing of the principal Ontario industrial dischargers, facility type and discharge volumes is presented in Table 5.24.

Refineries which include Esso Petroleum, Suncor Inc., Shell Canada and Novacor Chemicals (Canada) manufacture products including the following:

- gasoline, diesel, jet fuel;
- petrochemical feed stocks;
- lubricating oils and waxes;
- aromatic solvents;
- petrochemicals; and
- fuel co-products.

Numerous chemical manufacturing facilities including Esso Chemical, Polysar, Dow Chemical, Ethyl Canada, Du Pont Canada, and Chinook Chemicals produce a wide array of products including the following:

- polyethylene resins;
- solvents;
- polyvinyl chloride resins;
- styrene monomer;
- rubber latex and synthetic rubber;
- vinyl chloride monomer;
- trichloroethane;
- carbon tetrachloride;

Table 5.23 St. Clair River point source inventory, United States.

Name and Location	Type of Facility	Receiving Stream	Outfall Name	1989[1] Average Annual Flow 10^3 m^3/d (U.S. gal/day X 10^6)
MAJOR DIRECT DISCHARGERS				
Municipal				
Algonac WWTP, St. Clair County	Rotating biological discs, Phosphorus removal	St. Clair River	Final Effluent	6.32 (1.67)
Marine City WWTP	Trickling filter, Phosphorus removal	St. Clair River	Final Effluent	3.66 (0.97)
Marysville WWTP	Trickling filter, Phosphorus removal	St. Clair River	Final Effluent	8.59 (2.27)
Port Huron WWTP	Activated sludge, Phosphorus removal	St. Clair River	Final Effluent	41.56 (10.98)
St. Clair WWTP	Trickling filter, Phosphorus removal	Pine / St. Clair Rivers	Final Effluent	6.66 (1.75)
Industrial				
Detroit Edison Co., St. Clair Plant	Power plant cooling water	St. Clair River	Final Effluent	3,853.00 (1,017.90)
Detroit Edison Co., Marysville Plant	Power plant cooling water	St. Clair River	Final Effluent	795.00 (0.21)
Detroit Edison Co., Belle River Plant	Non-contact condenser cooling water	Belle / St. Clair Rivers	Final Effluent	1,770.00 (467.60)
AKZO Salt Inc., St. Clair	Sedimentation	St. Clair River	Final Effluent	7.19 (1.90)
James River KVP, Port Huron	Air flotation clarifiers	St. Clair River	Final Effluent	9.50 (2.51)
E.B. Eddy	Air flotation clarifiers	St. Clair/ Black Rivers	Final Effluent	25.17 (6.65)

Table 5.23 (Cont'd)

Name and Location	Type of Facility	Receiving Stream	Outfall Name	1985[2] Average Annual Flow 10^3 m^3/d (U.S. gal/day X 10^6)
MINOR DIRECT DISCHARGERS				
St. Clair Sewer Authority, East China Township WWTP	Rotating biological discs, Phosphorus removal	St. Clair River	Final Effluent	1.80 (0.48)
American Tape Co., Marysville	Cooling tower blowdown	St. Clair River	001	0.003 (0.0008)
Marine City WFP	Filter backwash	St. Clair River	001	4.30 (1.14)
Marysville WFP	Filter backwash	St. Clair River	001	
Port Huron WFP	Filter backwash	St. Clair River	001	250.00 (66.10)
Lawson Farms, Richmond	Lagoon	St. Clair River	Final Effluent	Unknown - minor
Detroit Edison Co. - Range Road Ash Disposal, St. Clair	Stormwater Lagoon	St. Clair River	001	0.60 (0.16)
Hanson Inc.	Non-contact cooling Stormwater	St. Clair River	001	0.11[a] (0.03)
St. Clair Vineyards	Non-contact cooling	St. Clair River	001	Unknown - minor
East China Charter Twp. WFP	Filter backwash	St. Clair River	001	0.04[a] (0.01)
Algonac WTP	Filter backwash	St. Clair River	001	0.08[a] (0.02)
Old Club WWTP	Package WWTP	St. Clair River	001	0.03[a b] (0.01)
MINOR INDIRECT DISCHARGERS				
CAPAC WWTP	Lagoon	Belle River	Final Effluent (seasonal)	0.90 (0.24)
Detroit Edison Co., Marysville Terminal	Stormwater	Bunce Creek	001	35.00 (9.25)
Empire Tool Co., Memphis	Non-contact cooling	Belle River	001	Unknown - minor
Memphis WWTP	Lagoon	Belle River	Final Effluent (seasonal)	1.90 (0.50)
Mueller Brass Co., Port Huron	Non-contact cooling water, stormwater	Black River	001	1.90 (0.50)
Smiths Creek Landfill, St. Clair	Lagoon	Pine River	001	0.00 (seasonal)

[1] MDNR District files 1989.
[2] Point Source Workgroup, UGLCCS (1988).
[a] MDNR 1991 Discharge Monitoring Reports (6 mo.).
[b] Facilities design flow

Table 5.24 St. Clair River point source inventory, Canada.

Name and Location	Type of Facility	Receiving Stream	Outfall Name	Average Annual Flow[1] 10^3 m^3/d (U.S. gal/d X 10^6)
DIRECT DISCHARGERS				
Municipal				
Sarnia WPCP	Primary with phosphorus removal (continuous)	St. Clair River	Final Effluent	35.64 (9.27)
Corunna WPCP	Extended aeration, Phosphorus removal (continuous)	St. Clair River	Final Effluent	1.96[a] (0.51)
Point Edward WPCP	Primary with phosphorus removal (continuous)	St. Clair River	Final Effluent	1.56 (0.41)
Courtright WPCP	Extended aeration, Phosphorus removal (continuous)	St. Clair River	Final Effluent	0.26[a] (0.07)
Sombra Lagoon	Conventional lagoon seasonal with batch phosphorus removal	St. Clair River	Lagoon Discharge	0.19 (0.05)
Industrial				
Esso Petroleum, Sarnia	Petroleum refinery	St. Clair River	Biox effluent Once through cooling water	210.00 total all outfalls (54.60)
Esso Chemical, Sarnia	Plastics and petrochemicals	St. Clair River	Final Effluent	30.41[a] (7.91)
Polysar Rubber Corp. and Novacor Chemicals (Canada) Ltd., Sarnia (Also an indirect discharger to Cole Drain)	Synthetic rubber, latex, plastic and petrochemicals	St. Clair River	Biox Effluent 54" sewer 66" sewer Stereo API 72" sewer	364.70 total all outfalls (94.82)
Dow Chemical Canada Inc., Sarnia	Petrochemicals, plastics, chlorine and caustic soda	St. Clair River	1st Street 42" sewer 1st Street 48" sewer 1st Street 54" sewer 2nd Street sewer 3rd Street sewer 4th Street sewer 5th Street sewer	762.67 total all outfalls (198.29)
Suncor, Sarnia	Petroleum refinery	St. Clair River	Impounding Basin Effluent Once through cooling water	90.00 total combined outfall (23.40)
Cole Drain, Sarnia	Municipal open ditch which conveys surface runoff and industrial process, cooling and storm water. Most of dry weather flow is industrial.	St. Clair River	Discharge to St. Clair	147.00[b] During point source survey (38.22)
Ethyl Canada, Corunna	Antilock compounds, lead free gasoline additives, anti-oxidants, aluminum alkyls	St. Clair River	Final Effluent	35.37 (9.20)
DuPont Canada Inc., Corunna	Polyethylene resins	St. Clair River	Final Effluent	49.11 (12.77)
Novacor Chemicals Ltd., Corunna	Polyethylene resins	St. Clair River	Final Effluent	1.50 (0.39)

Table 5.24 (Cont'd)

Name and Location	Type of Facility	Receiving Stream	Outfall Name	Average Annual Flow[1] 10^3 m^3/d (U.S. gal/d X 10^6)
Novacor Chemicals Ltd., Petrochemicals, Corunna	Petroleum refinery and petrochemical feedstock	St. Clair River	Final Effluent	5.80 total all outfalls (1.51)
Ontario Hydro Lambton Generating Station, Courtright	Coal fired generating station	St. Clair River	Filtration plant effluent Ashpond/Coalpile runoff pond overflow Once through cooling water	3,000.00 (780.00)
ICI Nitrogen Products, Courtright	Agricultural chemicals	St. Clair River	Final Effluent	4.69 (1.22)
INDIRECT DISCHARGERS				
Municipal				
Port Lambton Lagoon	Conventional lagoon seasonal batch phosphorus removal	Marshy Creek	Lagoon Discharge	0.42 (0.11)
Industrial				
Amoco Canada Ltd., Sarnia	Petrochemical feedstocks (Ethane, propane, butane, pentane)	Cole Drain	Cooling tower blowdown, storm runoff	0.03[b] (0.01)
CN Rail, Sarnia	Railway yard	Cole Drian	Storm water discharge	Not measured
Dow Chemical Scott Rd. Landfill, Sarnia	Carbon-treated landfill leachate discharge	Cole Drain	Treated leachate	Periodic discharge 0.00 or 0.29[b] (0.00 to 0.08)
Partek Insulation Ltd., Sarnia	Insulation	Scott Road ditch	Once through cooling water	No data
Fiberglass Canada Ltd., Sarnia	Fiberglass production	Cole Drain	Final Effluent (Process and cooling)	4.69 (1.22)
Cabot Carbon, Sarnia	Carbon black	Cole Drain	Final Effluent (Process and cooling)	0.55 (0.14)
Polysar Rubber Corp. and Novacor Chemicals (Canada) Ltd., Sarnia (Also an indirect discharger to Cole Drain)	Synthetic rubber and petrochemicals	Cole Drain	Storm Water	Not measured
Shell Canada Products Ltd., Corunna	Petroleum refinery	Talfourd Creek	Biox effluent Once through cooling water (2) Storm water	173.70 total all outfalls (45.16)
Chinook Chemical, Sombra	Methylamines, dimethyl foramide	Murphy Drain	Final Effluent	0.01[b] (0.002)

1 Data are for 1989 as reported in Chapter 8, unless otherwise noted.
a Data are for 1988 as reported in Chapter 8.
b Data are for 1985 as reported in UGLCCS (1988).

- tetrachloroethylene;
- propylene glycols;
- chlorine and caustic soda;
- polystyrene;
- anhydrous hydrochloric acid;
- vinyl ester epoxy resins;
- ethyl chloride;
- polyethylene plastics;
- polypropylene;
- methylamine derivatives;
- dimethyl formamide; and
- fertilizers.

Additional direct and indirect point source dischargers are situated along the St. Clair River and inland along tributaries to the river. These facilities include: ICI Canada Inc.; Partek Insulations Ltd.; Fibreglas Canada Ltd.; Cabot Canada Inc.; a number of municipal sewage treatment plants (Pt. Edward, Sarnia, Corunna, Courtright) and lagoons (Sombra, Port Lambton); as well as drains/ditches or tributaries which convey treated leachate from area waste disposal sites. Each of these operations is described in detail in Chapter 8.

Industries on the U.S. side of the river discharge relatively small amounts of effluent and, with the exception of two paper mills which discharge some process water, the effluent is primarily once-through cooling water or filter-backwash.

5.8.10.2 Nonpoint Sources

There are a variety of nonpoint sources of contamination to the St. Clair River. These include atmospheric deposition, urban and rural runoff, resuspension of contaminated sediments, groundwater, shipping-related discharges, and spills.

Atmospheric deposition of airborne pollutants directly to the AOC is negligible owing to the small surface area of its drainage basin. However, inputs to Lake Huron and its drainage basin are considerable due to its large surface area. Atmospheric contamination directly to Lake Huron flows into the St. Clair River. It is believed that most organochlorine pesticides found in the river, alpha-BHC, gamma-BHC (lindane), dieldrin and heptachlor epoxide come from upstream locations including Lake Huron. This is evidenced by the levels in the St. Clair River water column which do not show any crossstream or downstream concentration trends (UGLCCS 1988, p.255).

Urban runoff consists of both stormwater discharges and combined sewer overflows. Combined sewer overflows are considered point sources in Michigan and will be addressed in Chapter 8. Many municipalities have storm sewers which drain directly or indirectly into the river. In Michigan, Port Huron has 10 storm sewers discharging directly into the St. Clair River, and another 14 which discharge into the Black River. Marine City has three storm sewers which empty into the Belle River, and Algonac has two storm sewers discharging directly to the St. Clair River. Neither Marysville or St. Clair have stormwater discharges.

In Ontario, Sarnia has eight municipal storm sewer outfalls which discharge to the St. Clair River in addition to four combined sewer overflows and several private drainage outfalls. Some less developed areas of the city are drained by open channels. The most important open ditch draining into the St. Clair River is the Cole Drain running through the industrialized area south of Sarnia.

Surface runoff is thought to be the principal route of contaminant transport from many landfill sites located along the St. Clair River. At many sites, low hydraulic conductivity of surficial materials restrict infiltration and groundwater movement, forcing contaminated surface water to flow into storm drains and small tributaries.

Agricultural runoff occurs from about 238,000 ha (588,000 acres); more than 60 percent of this is under intensive cultivation (corn and soybeans). Livestock operations within the watershed are dominated by beef and dairy farming, followed by swine and poultry husbandry. Contaminants associated with these types of operations have traditionally included nutrients, particulates from soil erosion and fugitive pesticides and herbicides (Nonpoint Source Workgroup 1987a).

Sediments along the Ontario shoreline of the St. Clair River are contaminated with a variety of chemicals (Sediment Workgroup 1987 and Mudroch and Hill 1989). However, compared to chemicals in water and suspended sediments, much less than 1 percent of the contaminants moving downriver are transported by sediments (Carey et al. 1987). While desorption can be a significant source of contamination to overlying waters, it is unlikely that this process contributes significantly to St. Clair River water. However, because no measurements have been made, it is not possible to draw firm conclusions at this time (UGLCCS 1988, p. 284)

Sediments may also serve as a source of contaminants via the biological community. In this regard, benthic organisms have been shown to take up some contaminants from the sediment which can then be passed up through the food chain, often becoming more concentrated from one trophic level to the next.

Groundwater discharges to the St. Clair River can potentially result from three different flow systems: from surficial aquifers; from intermediate flow systems; and from deep bedrock systems (UGLCCS 1988, p. 269). While groundwater in the unconsolidated surface deposits generally flows to the St. Clair River, there are local variations in the direction of groundwater flow resulting from surface water drainage and glacial landforms. Groundwater flow directions in the deeper systems are not as well understood.

Total groundwater seepage to the St. Clair River from all sources has been estimated by three independant investigators to be between 645 L/s and 741 L/s, averaging approximately 700 L/s (182 U.S. gal/s) (UGLCCS 1988, p. 269). Although there is some uncertainty to these estimates, they suggest that only a very small fraction of the average flow (5.2 X 10^6 L/s or 1.4 X 10^6 U.S. gal/s) of the river is contributed by groundwater. Shallow groundwater in the study area does not flow directly into the St. Clair River; instead, it flows into tributaries, contributing approximately 10 percent of the stream flow to the river. While the total amount of groundwater discharge to the St. Clair River is only a very small fraction of the river's water budget, the high concentrations of contaminants found in groundwater in some areas make this route locally important (UGLCCS 1988, p. 269).

Spills are a commonplace occurrence, in the St. Clair River, owing to the heavily industrialized nature of the St. Clair River shoreline and associated shipping activities. They continue to be a major concern, as a single incident can result in loadings of a chemical which approach or exceed total annual loadings from all other sources. Spills which were reported in both Ontario and Michigan waters of the St. Clair River are listed and discussed in Chapter 8.

The large spill of perchloroethylene in 1985 from Dow Chemical received a great deal of publicity and brought attention to the potential for large scale spills and environmental degradation. Approximately 30,000 L (7,800 U.S. gal) of perchloroethylene, a toxic dry cleaning solvent, were spilled between August 13 and 16, 11,000 L (2,860 U.S. gal) of which reached the St. Clair River. Approximately 9,000 L (2,340 U.S. gal) of this material was recovered from the river bottom shortly after the spill occurred. Additional material was recovered in a sediment removal project later in that year.

Ship traffic through the St. Clair River is considered to have negligible effects on water quality (UGLCCS 1988, p. 289), aside from localized re-suspension of bottom sediments. However, ballast water, oily wastes and sanitary wastes are potential shipping related discharges. The recent introduction of the zebra mussel (*Dreissena polymorpha*) into the Great Lakes has underscored the potential dangers of discharging ballast waters. This nuisance organism was first found on the south shore of Lake St. Clair; its probable source is believed to be contaminated ballast water discharged near that location.

6.0 ENVIRONMENTAL CONDITIONS

6.0 ENVIRONMENTAL CONDITIONS

6.1 INTRODUCTION

This chapter summarizes the physical and chemical condition of, and associated impacts to, the St. Clair River Area of Concern (AOC). Data are included for the whole river, its major tributaries and the distributaries and marshes of the St. Clair Delta.

Section 6.2 provides information on the physical condition, primarily as it relates to the condition and loss of wetlands. Section 6.3 discusses the chemical condition of the AOC according to the three major media: water, sediment and biota. For each medium, information is presented on the concentration of contaminants, patterns of contamination within the AOC, trends over time (where data are sufficient), impacts (for example, changes in community structure of organisms), and relationship to relevant guidelines or objectives. A summary of the current data base on human health in the AOC is provided in Section 6.4.

This information provides the technical rationale for identifying impaired uses within the AOC. Impaired uses, based on those defined in the Great Lakes Water Quality Agreement (GLWQA), are highlighted in Chapter 7. Chapter 6 thus forms the basis for impaired use assessment and the identification of issues/uses requiring further assessment.

The last section of the chapter (6.5) provides an overall summary which attempts to show interrelationships among the various media in terms of the major findings.

For ease of interpretation and comparison, the units of concentration for data in text, tables and figures have been standardized primarily as follows:

- metals and organic contaminants in water are presented as parts per billion (μg/L); and
- major ions in water and all parameters in suspended solids, bottom sediments or biota are presented as parts per million (mg/L or μg/g).

6.2 PHYSICAL IMPACTS TO THE ST. CLAIR AOC.

6.2.1 Habitat Loss

Wetland communities common to the St. Clair River and delta were discussed in Chapter 5 (Section 5.4.2) along with their location and extent (Section 5.7.7.2). The importance and value of these resources, particularly as they relate to wildlife habitat, fisheries habitat, commercial and sport fishing, hunting and trapping, Native consumptive uses, and naturalist values, were clearly identified and documented in Chapter 5. The loss of these wetland resources, as well as other fish and wildlife habitat is considered a major concern in the AOC.

Edsall et al. (1988a) and McCullough (1985) described some of the losses of the aquatic plant community that have occurred over time due to industrial, agricultural and urban developmental pressures. Many of the wetlands of the St. Clair system have been lost, primarily because of drainage of large tracts of land for agriculture although Martz (MDNR, pers. com.) suggests that considerable wetland acreage was also lost due to dredging or filling related to marina and housing developments. In addition, many wetlands have been seriously impaired by dykes that block them from the lake. This has occurred for a variety of purposes ranging from a desire to manage a site exclusively for waterfowl, to preventing trespassing. Invariably this results in a number of impairments such as loss of hydrological functions of the wetland and the loss of fish habitat. The following information on wetland loss has been modified from Edsall *et al.* (1988a).

1. In 1873, the Michigan side of lake St. Clair and the St. Clair Flats supported 7,274 ha (17,975 acres) of wetland vegetation (Table 6.1); by 1973, the habitat was reduced to 2,020 ha (5,000 acres), a 72 percent loss. Significant losses occurred not only in the St. Clair Delta and St. John's Marsh, but on the entire margin of the lake as well (Figure 6.1). Some coastal areas, particularly north of the Clinton River, appear to have been drained for agriculture in the 1860s, so the 1873 data (Figure 6.1) do not include the entire wetland acreage that existed prior to European settlement.

Table 6.1 Michigan and Ontario wetland losses on Lake St. Clair.*

Michigan Location	Wetland Area		
	1868-73 (ha)	1973 (ha)	Loss (ha)
St. Clair Flats	5,473	1,779	3,694
Swan Creek	75	2	73
Marsac Point	61	2	59
New Baltimore	21	0	21
Salt River	162	18	144
Clinton River	1,295	221	1,074
Gaukler Point	187	0	187
Total	7,274	2,022	5,252

Ontario Location	1965 to 1984 Area Loss (ha)	Wetland Type	Cause
Thames River	59	diked	agriculture
Thames River mouth	115	open	marine/cottage construction
Bradley Marsh	327	diked	agriculture
Balmoral Marsh	11	diked	agriculture
Snake Island Marsh	156	diked	agriculture
St. Lukes Bay	22	diked	agriculture
Patricks Cove	60	diked	agriculture
Mitchells Bay	7	open	agriculture
Mud Creek Marsh	307	diked	agriculture
Total	1064		

* Data sources: Jaworski and Raphael (1976), McCullough (1985).

2. The Ontario wetlands from the Thames River north to Chenal Ecarte dwindled from 3,574 ha (8,830 acres) in 1965 to 2,510 ha (6,200 acres) in 1984 (McCullough, 1985). Figure 6.2 and Table 6.1 present specific areas of wetland losses in the coastal Ontario wetlands between 1965 and 1984. As indicated, losses have occurred within the Walpole Island Indian Reserve and along the eastern shores of Lake St. Clair (Table 6.1). Drainage for agriculture accounted for 92 percent of the losses, and marina and cottage development consumed the remaining 8 percent. During the record high

Figure 6.1

St. Clair River Remedial Action Plan

Extent of Lake St. Clair coastal wetlands in 1873 and in 1968

(Herdendorf et al. 1986)

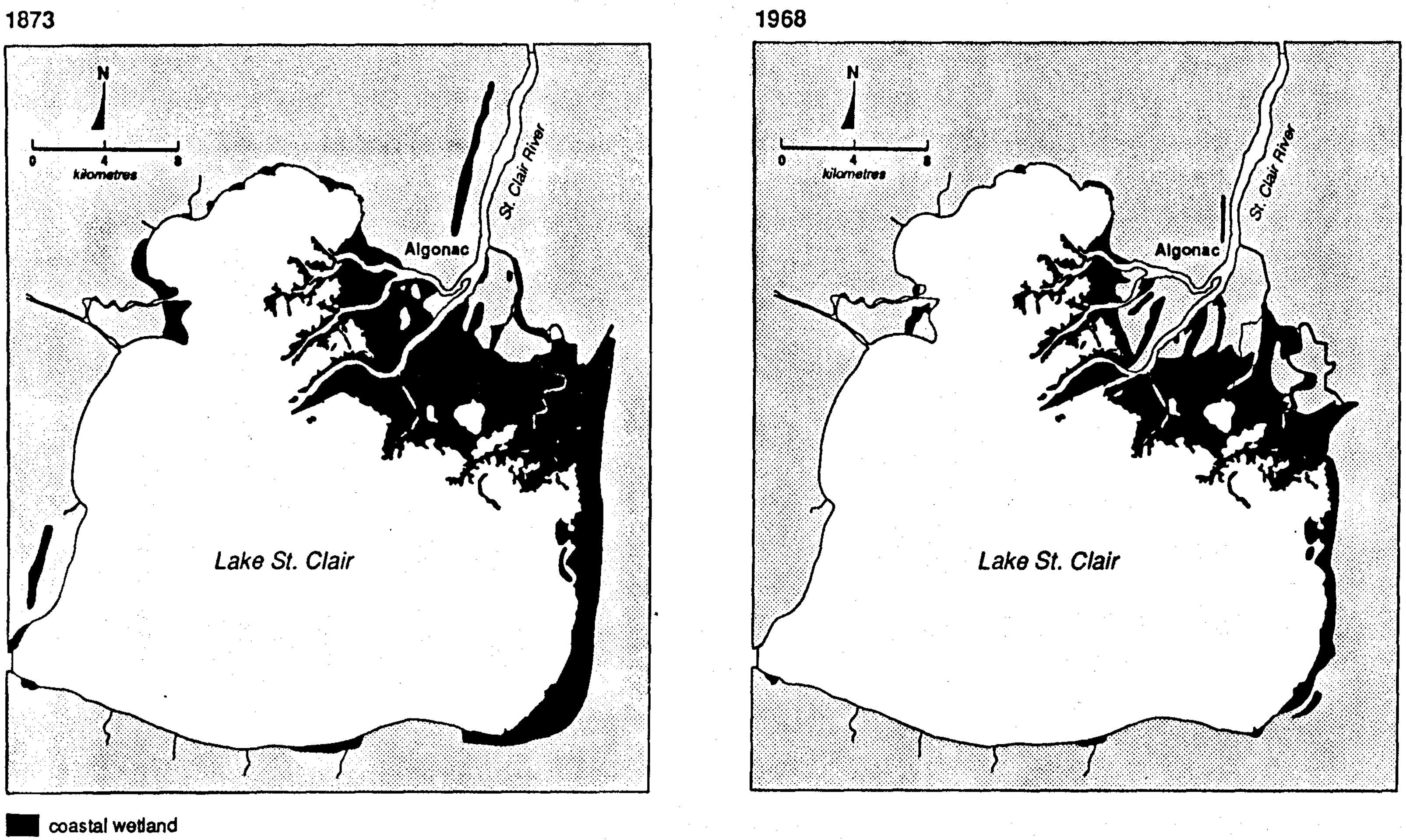
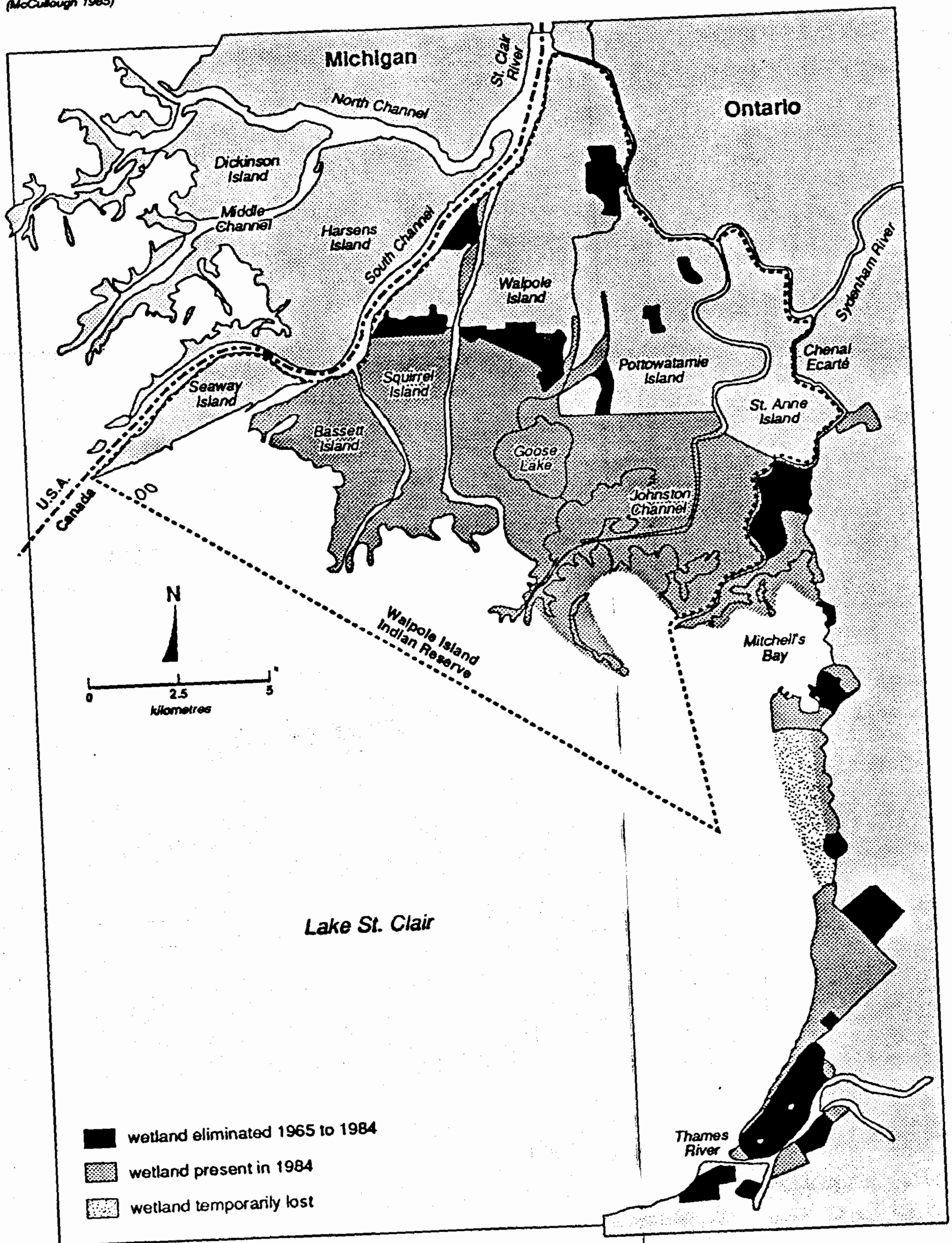


Figure 6.2

St. Clair River Remedial Action Plan

Wetland losses in the Ontario portion of Lake St. Clair from 1965 to 1984

(McCullough 1985)



lake level in the early 1970s, about 1,000 ha (2,470 acres) of emergent shoreline marsh from Mitchell Bay southward to the Thames River were also temporarily lost (McCullough 1985). This loss was tempered in part by the flooding of transition vegetation on the upland (east) margin of the wetlands. The St. Clair Flats and Anchor Bay in Michigan are also subject to flooding, but most of the recent wetland losses there are due to diking and filling for urban development.

3. In Ontario, the coastal zone north of the Thames River was once an open marsh, but over the decades many dikes have been constructed, and the enclosed marshes have been colonized with cattails. Although the shoreline in these areas remains as wetland, the diking has separated it from the inland portions of the wetland and altered the hydrology. These diked Ontario wetlands (like those on Harsens Island in Michigan) are effectively managed for waterfowl hunting and the result is a loss of other diverse wetland functions, particularly those related to fish production. The adverse impact of isolating and fragmenting wetlands by means of roadbeds, canals, earthen dikes and other developments appears not be to fully recognized. For example, many conservationalists in Michigan are advocating the preservation of St. John's Marsh, but few call for an increase in its hydrologic connectivity to Lake St. Clair. Moreover, unless a wetland is physically destroyed, not merely fragmented or disconnected from a lake, most people would not refer to an isolated wetland as being impaired or degraded.

4. Wetland losses exceed those shown in Table 6.1 and Figures 6.1 and 6.2, if the definition of wetlands is expanded to include areas colonized by submersed vegetation. While data are not available specifically for the St. Clair system, Jaworski and Raphael (1976) have shown that more than 9,000 ha (22,250 acres) of wetlands were actually lost to shoreline development in Lake St. Clair (Table 6.2) between 1873 and 1968, if submergent macrophytes are added to the total wetland habitat. Losses are most evident in the Clinton River, the St. Clair delta, and along the eastern shore of the lake.

Table 6.2 Lake St. Clair wetland losses, 1873-1968 (Jaworski and Raphael, unpublished data).

Location	Wetland Area (ha)				Loss (ha)
	Michigan		Ontario		
	1873	1968	1873	1968	
St. Clair Delta	5,414	3,077	9,641	7,234	4,744
Clinton River	1,192	248	-	-	944
Remaining Shoreline	1,900	806	4,219	1,862	3,451
Total	8,506	4,131	13,860	9,096	9,139

In addition to habitat losses documented for the delta, there have been extensive alterations to the shoreline and inland areas upstream of the delta. These losses are due to industrial, agricultural and urban development throughout the watershed of the AOC. The overall extent of the loss of wetland and shoreline habitat within the watershed has not been well documented. Extensive bulkheading and infilling has occurred along much of the river resulting in the loss of spawning, rearing and feeding sites for many fish species. The preservation of the remaining unaltered wetland and shallow water nearshore areas is extremely important for the maintenance of a healthy, diverse fish community.

6.2.2 Wildlife Populations

Changes in waterfowl use between 1968 and 1982 in the wetlands along the east shore of Lake St. Clair and on the Walpole Island Reserve was studied by Dennis and North (1984). The shoreline marshes of Lake St. Clair and Lake Erie are considered the most extensive and highest quality habitat for migratory waterfowl in Ontario, south of James Bay. Of the 13,700 ha (33,839 acres) of wetland examined, 9,800 ha (24,206 acres), or 76 percent, were within the Walpole Island Reserve. Much of this land is leased by hunt clubs.

Dennis and North (1984) estimated peak numbers of waterfowl to be 150,000 birds in these marshes in the fall. Use of this area during the autumn has shown an overall increase of 37 percent between 1968-1982. This is a result of nearly twice as many mallards, three times as many geese and fourteen times as many swans. However, some ducks have declined in numbers. For example, there has been a 14 percent decline in the use of this area by diving ducks during the fall.

Spring use of this area has shown little change between 1968 and 1982 in terms of the peak number of waterfowl which is estimated at 60,000 individuals (Dennis and North 1984). However, use of the area by dabbling ducks, such as American widgeon, green-winged teal, blue-winged teal and wood ducks, has decreased (McCullough 1985). Between 1968 and 1982, spring use by these species decreased by 79 percent, while fall use has declined by 41 percent. Use of the marshes by diving ducks during the spring has more than doubled. There has also been some increase in the number of geese and swans visiting the area in the spring.

Overall increases in wetland use are attributed to expanded populations of mallards, tundra swans and Canada geese, an increase use of baited sanctuaries (i.e., a cost effective way of increasing hunting success), and the establishment of a National Wildlife Area on the Ontario shore of Lake St. Clair. The reduction in use by certain species in the fall or spring is attributed to pressures such as the drainage and subsequent loss of wetland areas, increased boat traffic, increased hunting on portions of the wetlands owned by the Walpole Indian Band and population declines of species such as black ducks and ruddy ducks. Continent wide wetland loss is a factor to migrating bird survival, but this has not been assessed for the St. Clair wetland species.

There are no data available on trends in the use of the AOC for other wildlife species.

Dennis and North (1984) and McCullough (1985) predict that further development of the wetlands in the form of agricultural drainage, navigation and hunting will result in large reductions in use of the wetlands by most species of waterfowl. The delta is home to many native species including many which are rare and endangered (Chapter 5, Section 5.8.3). It also serves as an important dietary supplement for residents of the Walpole Island Indian Reservation (Great Lakes Institute 1987). The remaining wetlands of the delta are thus an extremely valuable resource which should be protected from physical and chemical impacts.

6.3 CHEMICAL CONDITION

6.3.1 Water Quality

The discussion on water quality is summarized by parameter or class of parameter and each is discussed in terms of historical as well as the most current information. Data are compared to objectives, standards and guidelines for the protection of aquatic life, human contact (bacteria) or nuisance algae/weed growth (total phosphorus). Water quality objectives utilized are the Ontario Provincial Water Quality Objectives (PWQO, OMOE 1984) and the Great Lakes Water Quality Agreement Specific Objectives (GLWQA). Water quality standards are the Michigan Water Quality Standards, (November 1986) including Rule 57 values for toxic substances as updated in January 1991. Water quality guidelines are the PWQ Guideline for total phosphorus and the Canadian Water Quality Guidelines (CCREM 1987).

Parameters discussed in this section include physical parameters - temperature, colour, specific conductance and turbidity; conventional parameters - ammonia nitrogen, total phosphorus, chloride and bacteria; trace metals - mercury, lead, iron, zinc, copper, nickel, cobalt, cadmium and chromium; and organic contaminants - pesticides, PCBs, chlorinated industrial organics (such as octachlorostyrene, hexachlorobenzene, pentachlorobenzene), and volatile organics (such as tetrachloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, chloroform). Additional information relating to possible use impairments due to water quality problems are discussed in terms of drinking water treatment plant intake closures, taste and odour problems and aesthetics.

Data sources for mercury, lead, iron, zinc and organic contaminants are primarily large-scale ambient survey programs conducted from 1977 through 1986/87 by government agencies. These sources are cited where utilized and the reader should refer to the documents for complete information on sampling and analytical methods. Data for colour, specific conductance, turbidity, ammonia nitrogen, total phosphorus, chloride, copper, nickel, cobalt, cadmium and zinc are primarily taken from raw water samples collected at the intakes of three Ontario water treatment plants (WTP) as part of the Ontario Ministry of the Environment's (OMOE) Drinking Water Surveillance Program (OMOE 1986, 1987 & 1990).

The location of these facilities represent upstream conditions (Lambton WTP - Lake Huron water) and downstream conditions (Walpole Island - South Channel; and Wallaceburg - Chenal Ecarte). Their locations are shown in Figure 6.3. Sampling and analysis was undertaken by OMOE. Data for 1985 are based on samples collected weekly or biweekly during the months of November, December and January 1986. The Wallaceburg Water Treatment Plant also took samples monthly from June through October, 1985. Raw water samples for 1986 were taken monthly from May through September. For 1988, samples were taken monthly throughout the year with bimonthly sampling mostly in June, November and December.

6.3.1.1 Temperature

Temperature can affect the physical, biological and chemical processes in the aquatic environment. For example, increasing water temperature decreases the solubility of oxygen in water while increasing the oxygen demand of fish (McNeely et al. 1979). The solubility of many chemical compounds will increase with an increase in temperature and may influence the effect of pollutants on aquatic life (McNeely et al. 1979). The Provincial Water Quality Objective for temperatures require no significant change to the diversity, distribution and abundance of plant and animal life. The ambient water temperature is not to be exceeded by more than 10 C at the edge of the mixing zone. The Michigan Water Quality Standards state that "No heat load which would warm receiving waters at the edge of the mixing zone more than 3 degrees Fahrenheit above existing natural water temperature for the Great Lakes and their connecting waters".

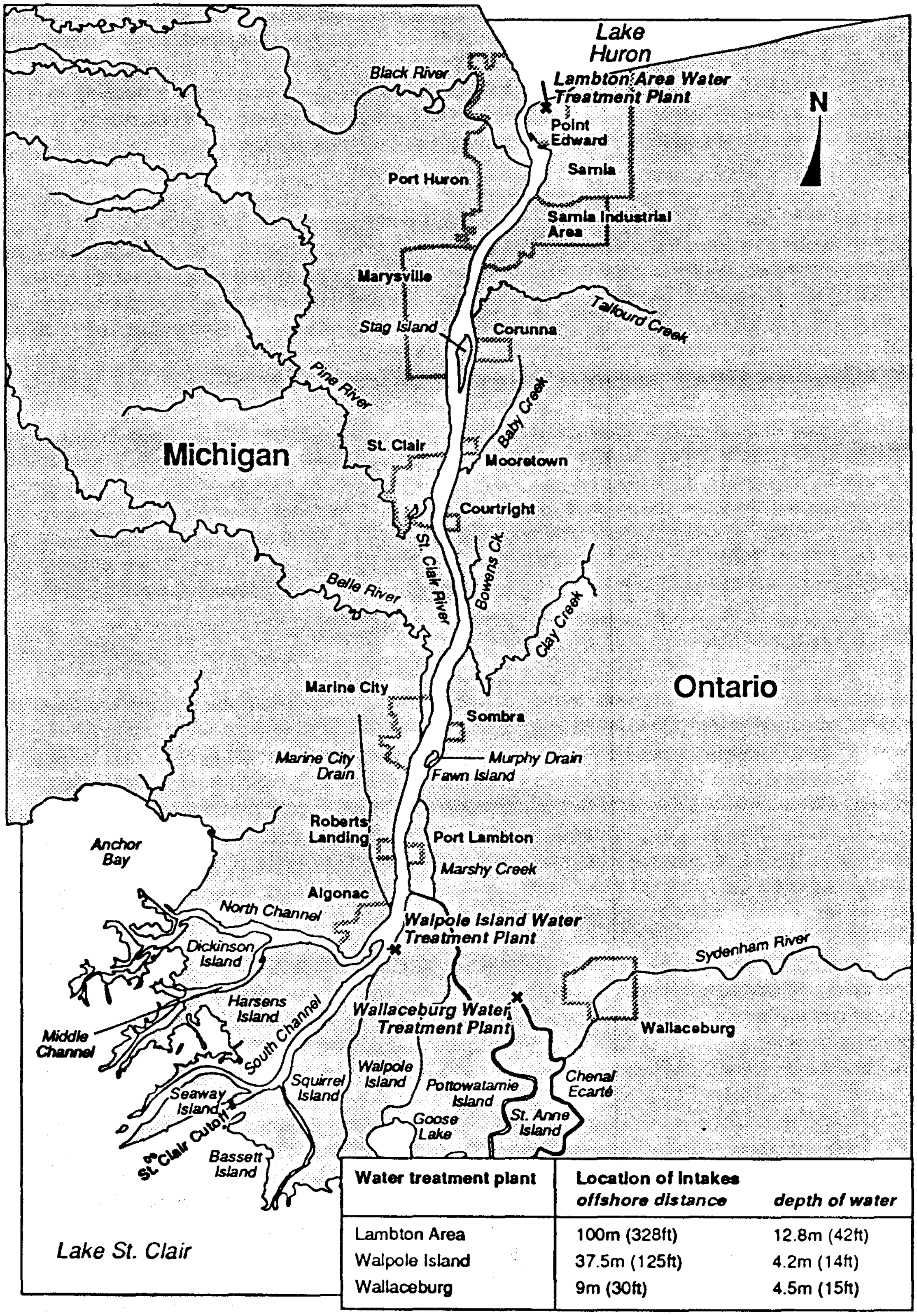
Natural bodies of water exhibit seasonal and diurnal variations, as well as vertical stratification in temperature. Water temperatures in the St. Clair River reach an annual minimum of 0.5 C in January and February and the annual maximum of about 21-22 C in August (Edsall et al. 1988a). These water temperatures were measured at the Port Huron intake from 1974 to 1984. The source of the river is Lake Huron and hence summer temperatures tend to be high reflecting the warming of surface waters in the lake.

St. Clair River waters are well-mixed vertically. Surface to bottom temperatures vary by no more than 0.2°C. Little variation occurs across the river, with average and maximum temperature differences of 0.2°C and 2.2°C, respectively, between nearshore and mid-channel locations (UGLCCS 1988). Ambient head and mouth surveys of temperature would not necessarily identify whether exceedences of guidelines have occurred. Temperature is monitored for specific outfalls according to a company's control permit and this information is provided in Chapter 8 (Sources).

Figure 6.3

St. Clair River Remedial Action Plan

Location of Intakes for the Lambton, Walpole Island and Wallaceburg Water Treatment Plants



Water treatment plant	Location of intakes *offshore distance*	*depth of water*
Lambton Area	100m (328ft)	12.8m (42ft)
Walpole Island	37.5m (125ft)	4.2m (14ft)
Wallaceburg	9m (30ft)	4.5m (15ft)

6.3.1.2 Colour

Colour is not normally considered a serious pollution problem, although colour may be detrimental in that it interferes with the passage of light, thereby impeding the photosynthesis of aquatic plants. Guidelines suggest that no undue increase in the colour of natural waters be allowed through waste disposal or other activities (McNeely et al. 1979).

Organic and inorganic materials contribute to the colour of water. There are two basic measures of water colour. True Colour Units (TCU) is measured after the removal of suspended matter and, hence, represents colour contributed from dissolved constituents only. There are no Provincial Water Quality Guidelines for colour in ambient waters. The Michigan Water Quality Standards do not specify a value but indicate that "waters of the state shall not have any of these [includes colour, oil films, solids and turbidity] unnatural physical properties in quantities which are or may become injurious to any designated use".

The clarity of the St. Clair River is exceptionally high and the region is often referred to as 'Blue Water Country' by local tourist agencies (Edsall et al. 1988a). Its aqua or blue-green colour is retained even under stormy conditions.

Results in Table 6.3 show raw water samples, at both the head and mouth of the St. Clair River have become clearer from 1985 to 1988. In 1985 there was a marked increase in colour downstream, however, this was reversed in 1986 and only slightly apparent in 1988. The reason for the high colour values at Walpole Island and Wallaceburg in 1985 is not known. However, water colour has improved (based on TCU values) since 1985 and the lack of downstream increases in TCU during 1988 indicate that impairment to colour from industrial and municipal discharges on the Ontario side of the river are not a concern for the St. Clair River AOC.

Table 6.3 Annual mean, range and number of samples (in brackets) of colour determinations for raw (ambient water quality) water samples taken at 3 water intakes from 1985 through 1988. Values are reported as TCU, True Colour Units.

LOCATION	1985[1]	1986[2]	1988[3]
Lambton	3.7 3.5 - 4.0 (2)	3.5 (1 only)	0.83 0.5 - 1.0 (12)
Walpole Island	7.0 2.0 - 18.0 (4)	2.7 2.5 - 3.0 (3)	0.96 0.5 - 2.0 (15)
Wallaceburg	20.1 2.0 - 56.0 (8)	NA	0.96 ND - 3.0 (15)

NA-not available
ND-below detection level
[1] OMOE 1985 Drinking Water Survey
[2] OMOE 1986 Drinking Water Surveillance Program.
[3] OMOE 1988 Drinking Water Surveillance Program.

6.3.1.3 Specific Conductance

Specific conductance (conductivity) is a numerical expression of a water's ability to conduct an electrical current. The conductivity of water is dependent on its ionic concentrations (total dissolved solids) and temperature. Specific conductance is particularly sensitive to variations in dissolved solids. An increase in dissolved solids results in an increase in conductivity (McNeely et al. 1979).

Guidelines have not been established to regulate specific conductance since the high values are found to correlate with total dissolved solids for which specific objectives have been defined. It should be noted that industrial wastes can elevate the specific conductance of receiving waters (McNeely et al. 1979).

Specific conductance, determined from raw water samples taken at the water intakes for Lambton (Sarnia) at the head of the St. Clair River, Wallaceburg at Chenal Ecarte and Walpole Island from the South Channel at the mouth of the river, are shown in Table 6.4. The values indicate slightly higher conductivity near the mouth than at the head of the St. Clair River.

More detailed surveys of specific conductance were undertaken for the whole river during 1986-87 as part of the St. Clair River MISA Pilot Site Investigation (OMOE 1990a). Results are shown in Figure 6.4 which is based on mean values of surface and bottom samples obtained at a 43 station grid. Conductivity increases dramatically from the head of the river to the Sarnia industrial area. Relatively high values occur in the Ontario shore panel throughout the Sarnia industrial area. The conductivity gradually decreases toward the mouth of the river where it is only slightly higher than at the head. There is little or no increase in conductivity along the Michigan shore. This pattern of conductivity reflects large volume inputs of total dissolved solids from industrial and municipal sources on the Ontario side of the river.

6.3.1.4 Turbidity

Turbidity is a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms in water which are usually held in suspension by turbulent flow (McNeely, 1979). The Ontario Provincial Water Quality Objective (PWQO) for ambient water turbidity requires <10 percent Secchi depth increase (OMOE 1984). The Michigan Water Quality Standards do not specify a value but indicate that "waters of the state shall not have any of these [includes colour, oil films, solids and turbidity] unnatural physical properties in quantities which are or may become injurious to any designated use".

Aerial photographs, taken on June 20, 1984 reveal a distinct turbidity plume entering the St. Clair River from along the nearshore areas of lower Lake Huron (Johnson and Kauss 1987). The two nearshore panels were separated by a wide zone of cleaner water. Sediment from upstream Lake Huron is thus likely the primary source of turbidity in nearshore waters of the St. Clair River.

Secchi disc data are not available for the St. Clair River. However, turbidity has been measured in raw water samples based on the degree of reflectance of a beam of light. The results are expressed as Formazin Turbidity Units (FTU).

Turbidity in raw water at the Lambton, Wallaceburg and Walpole Island WTPs are shown in Table 6.5. Values show an increase in turbidity downstream in the St. Clair River especially in the Chenal Ecarte (Wallaceburg water intake). This may be the result of any or all of industrial or municipal waste discharges, runoff from urban and agricultural areas and/or natural shoreline erosion of the river bank. The watershed of the St. Clair River consists of fine glacial lake plain clays which are under agricultural production. Surface and channel erosion from these areas are thus one source of the suspended particles. It is not known how much of the observed increase in ambient turbidity is the result of waste discharges. FTU units of turbidity measurement (Table 6.5) cannot be compared to Secchi depth, hence it is not known if the Provincial ambient guideline is exceeded.

Figure 6.4

St. Clair River Remedial Action Plan

Spatial distribution of specific conductance (conductivity) in the St. Clair River, 1986

Based on depth averaged concentrations for all samples collected during May 26-29, July 14-17 and October 20-23 (OMOE 1990a)

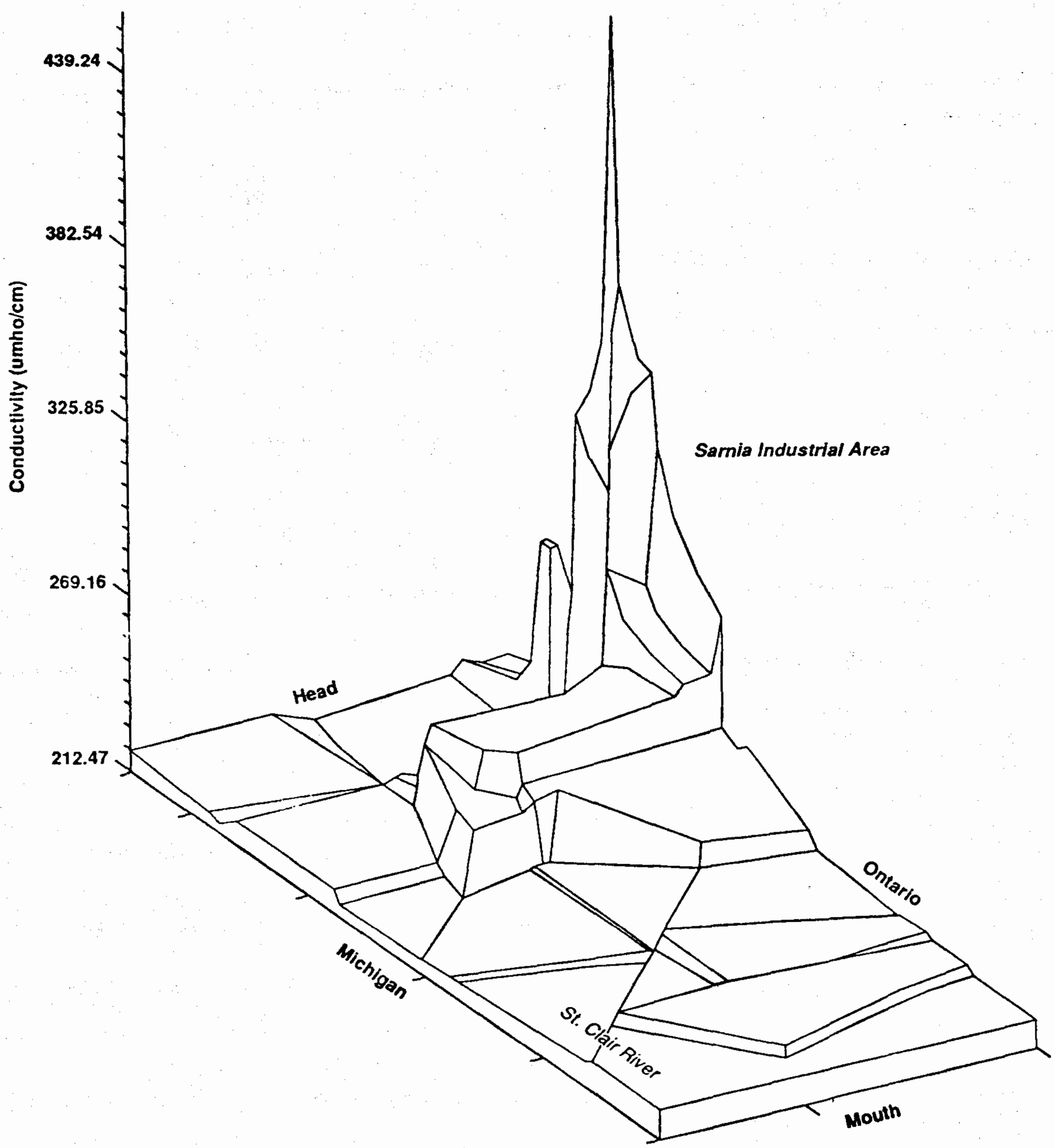


Table 6.4 Annual mean, ranges and number of samples (in brackets) for specific conductance in raw (ambient water quality) water samples taken at 3 water intakes from 1985 through 1988. Values are reported as µmhos/cm .

LOCATION	1985[1]	1986[2]	1988[3]
Lambton	210.5 210 - 211 (2)	213 207 - 219 (9)	218 213 - 225 (12)
Walpole Island	225 223 - 230 (4)	226 221 - 231 (4)	232 223 - 236 (15)
Wallaceburg	292 220 - 536 (8)	NA	236 230 - 247 (14)

NA-not available
1 OMOE 1985 Drinking Water Survey.
2 OMOE 1986 Drinking Water Surveillance Program.
3 OMOE 1988 Drinking Water Surveillance Program.

Table 6.5 Annual average, ranges and number of samples (in brackets) for turbidity in raw (ambient water quality) water samples taken at 3 water intakes from 1985 through 1988 with values determined in the field. Values are reported as FTU, Formazin Turbidity Units.

LOCATION	1985[1]	1986[2]	1988[3]
Lambton	2.86 2.70 - 7.00 (2)	3.22 0.50 - 8.60 (9)	2.02 0.35 - 15.20 (11)
Walpole Island	6.16 1.80 - 17.10 (5)	3.43 2.20 - 6.40 (4)	4.93 1.36 - 14.10 (15)
Wallaceburg	17.53 2.40 - 147.00 (8)	NA	5.12 0.81 - 13.9 (14)

NA-not available
1 OMOE 1985 Drinking Water Survey.
2 OMOE 1986 Drinking Water Surveillance Program.
3 OMOE 1988 Drinking Water Surveillance Program.

6.3.1.5 Ammonia Nitrogen

Ammonia nitrogen occurs in small concentrations in natural waters. It is the chief product of ammonification, the first stage in the nitrogen cycle. Ammonia may be used by certain nitrifying bacteria which in turn release nitrite. Nitrite is oxidized to nitrate very rapidly under aerobic conditions. The oxidation process from ammonia to nitrate is usually rapid. Thus, high concentrations of total ammonia (NH_3 + NH_4^+) indicate significant inputs of either organic matter or ammonia or both (Limno-Tech 1985), such as from point sources.

Ammonia and total Kjeldahl nitrogen (which includes ammonia) concentrations in the St. Clair River were measured by OMOE in 1977 (OMOE 1979). Surface water (60 locations) and bottom water (35 locations) samples were collected from throughout the river in conjunction with biological surveys during 1977 (OMOE 1979). Sample locations are provided in Appendix 6.1. The OMOE study accurately depicted the shoreline effects related to the St. Clair River hydraulics and heavy industry discharges along the shore. At nearly every transect sampled by this survey the ammonia concentrations were found to be lower in mid-stream than along the shore. Relatively high concentrations were found immediately downstream of outfalls for Esso Petroleum, Polysar, Dow and ICI along the Canadian shore. The highest concentration of total Kjeldahl nitrogen (1.4 mg/L) was found at the mouth of Talfourd Creek. The Provincial Water Quality Objective and Michigan Water Quality Standard for un-ionized ammonia was exceeded in bottom water at this location (OMOE 1979). All other samples (bottom and surface samples) were below the objective.

Total ammonia is analyzed as part of OMOE's Drinking Water Surveillance Program. Results for 1985, 1986 and 1988 are shown in Table 6.6. The water intake analyses show that during 1986 and 1988 all mean concentrations of total ammonia are less than or equal to 0.025 mg/L with the maximum value recorded at Wallaceburg (0.04 mg/L). The 1985 concentrations were less than detection, however, the analytical method for determining total ammonia changed after 1985 (Table 6.6). Although the mean concentration of total ammonia increased slightly from the head (Lambton) to the mouth of the river, the data are generally within the same range at all three locations.

Table 6.6 Annual mean, ranges and number of samples (in brackets) for total ammonia in raw (ambient water quality) water samples taken at 3 water intakes from 1985 through 1988. Values are reported in mg/L.

LOCATION	1985[1]	1986[2]	1988[3]
Lambton	ND (1)	0.016 0.008 - 0.024 (6)	0.014 0.002 - 0.034 (12)
Walpole Island	ND (3)	0.025 0.016 - 0.032 (4)	0.019 0.012 - 0.028 (15)
Wallaceburg	<0.10 ND - 0.10 (7)	NA	0.025 0.012 - 0.040 (14)

NA-not available
ND-below detection (detection limit was 0.05 in 1985 and 0.002 in subsequent years).
[1] OMOE 1985 Drinking Water Survey.
[2] OMOE 1986 Drinking Water Surveillance Program.
[3] OMOE 1988 Drinking Water Surveillance Program.

The PWQO, Michigan WQS (January 1991), Rule 57 value and Great Lakes Water Quality Agreement Specific Objective for unionized ammonia is 0.02 mg/L (for coldwaters). This value was exceeded at the mouth of Talfourd Creek in 1977, however, in 1986 and 1988 at the WTP intakes, the maximum value of total ammonia (i.e., NH_3 + NH_4^+) was 0.04 mg/L (Table 6.6). Because unionized ammonia usually forms less than 20 percent of total ammonia (i.e., pH and temperature dependent), it is unlikely that these ambient values exceeded the PWQO or Michigan WQS.

6.3.1.6 Total Phosphorus

Total phosphorus is the sum of all forms of suspended, dissolved and adsorbed phosphorus. Phosphorus is an important water quality indicator because it is the essential and often limiting element for plant growth. Controlling discharges of phosphorus is the primary strategy for reducing and eliminating eutrophication.

The OMOE measured total phosphorus concentrations in surface water and bottom water (35 locations) throughout the river during 1977 (OMOE 1979, Appendix 6.1). Concentrations in surface water ranged from 0.002 mg/L to 0.077 mg/L with an average of 0.012 mg/L. The highest value was found near the Ontario shore downstream of ICI Ltd (upstream of Sombra). Concentrations in bottom water (1 m/3.28 ft from bottom) were more variable with highest values found along the Ontario shore downstream of Esso Petroleum (0.067 mg/L) and at the mouth of Talfourd Creek (0.234 mg/L). Shoreline effects were found to be evident and exist along nearly the entire length of the river (OMOE 1979). No surface stations exhibited average total phosphorus concentrations (average of 6 samplings) above the Provincial Water Quality Guideline (0.03 mg/L) although 19 percent of stations had maximum concentrations above the guideline. The guideline was also exceeded in 20 percent of bottom water stations.

In 1984, the U.S. Environmental Protection Agency (EPA) Great Lakes National Program Office sponsored a sampling program on the St. Clair River. Sampling stations bracketed Sarnia's Industrial area and the City of Courtright, Ontario. Concentrations of total phosphorus found by this study were similarly in the order of 0.01 mg/L.

The most recent information for total phosphorus in ambient water of the St. Clair River are from samples taken at the Lambton (Sarnia), Walpole Island and Wallaceburg water intakes (Table 6.7). This information indicates that concentrations of total phosphorus continue to be low (0.006-0.02 mg/L). Since 1985 they have been well below the Provincial Water Quality Guideline for rivers of 0.03 mg/L. Although the concentration of total phosphorus increased slightly in the downstream direction, there is no clear, consistent trend (Table 6.7).

There is no clear trend with respect to phosphorus concentrations in the St. Clair River. The waters of the river have not been sampled intensively for total phosphorus because there have never been documented nuisance growths of algae or rooted aquatic plants in the river. Phosphorus concentrations were, on average, well below the 0.03 mg/L PWQ Guideline to protect against nuisance plant growths during 1986 and 1988. At Wallaceburg during 1985, 42.8 percent (3 of 7) of samples exceeded the guideline. During 1986 and 1988 only one exceedence was recorded. This occurred at the Walpole Island intake during December 1988 (0.045 mg/L).

6.3.1.7 Chloride

Chloride occurs in all natural waters in widely varying concentrations. Sewage effluents and many industrial wastes add considerable amounts of chloride to receiving waters (Limno-Tech 1985). In fresh water systems, elevated levels of chloride can be used as a general pollution indicator. In addition, surface runoff from urban areas where salt is used for de-icing may contribute significantly to the overall chloride load.

Table 6.7 Annual mean, ranges and number of samples (in brackets) for total phosphorus concentrations in raw (ambient water quality) water samples taken at 3 water intakes from 1985 through 1988. Values are reported in mg/L.

LOCATION	1985[1]	1986[2]	1988[3]
Lambton	ND (1)	0.01 0.009 - 0.014 (3)	0.005* ND - 0.014 (11)
Walpole Island	<0.02 ND - 0.02 (3)	0.008 0.008 (2)	0.008 0.002 - 0.045 (15)
Wallaceburg	0.05* ND - 0.20 (7)	NA	0.008 0.002 - 0.013 (15)

NA-not available
ND-below detection (0.01 mg/L in 1985, 0.002 after 1985)
[1] OMOE 1985 Drinking Water Survey.
[2] OMOE 1986 Drinking Water Surveillance Program.
[3] OMOE 1988 Drinking Water Surveillance Program.
* Non detects included as 0 mg/L.

The 1977 Ontario Ministry of the Environment survey found chloride concentrations as high as 270 mg/L nearshore while values as low as 5 mg/L have been found midstream. The spatial variation of the results again confirms the hydraulic flow of the St. Clair River. The highest chloride concentrations were found downstream of industrialized areas (Limno-Tech 1985). The U.S. EPA survey in 1984 indicated surface water chloride concentrations increase from 6.3 mg/L upstream of Sarnia to 22.3 mg/L downstream of Sarnia (Limno-Tech 1985).

Ambient water sampling from the 1986 MISA Pilot Site Investigation, reported chloride concentrations ranging from 3.25 mg/L to 105 mg/L (OMOE 1990a). The highest levels of chloride were found adjacent to the industrial waterfront at Sarnia. A rapid dropoff is observed with increasing distance downstream as well as lateral distance from the Ontario shoreline. The spatial distribution of chloride concentration is illustrated in Figure 6.5 (OMOE 1990a). This figure represents mean values of surface and bottom samples collected at a 43 station grid.

Chloride measured from water samples taken at the Lambton (Sarnia), Walpole Island and Wallaceburg water intakes (Table 6.8 also show an increase in values both downstream and over time). There is no PWQO for chloride, however, the concentration pattern indicates that industrial and municipal wastes are contributing to the total loading in the AOC (Figure 6.5).

The Michigan Surface WQS (January 1991) for chloride states that chlorides should not exceed 50 mg/L monthly average in Great Lakes waters or their connecting channels (Chapter 4). The highest concentrations measured in 1986 offshore of the Sarnia industrial waterfront (OMOE 1990a) exceeded this standard by up to two times. Concentrations of chloride at the three Ontario Water Treatment Plant intakes did not exceed or approach the Michigan standard (Table 6.8).

Figure 6.5

St. Clair River Remedial Action Plan

Spatial distribution of chloride in the St. Clair River, 1986

Based on depth averaged concentrations for all samples collected during May 26-29, July 14-17 and October 20-23 (OMOE 1990a)

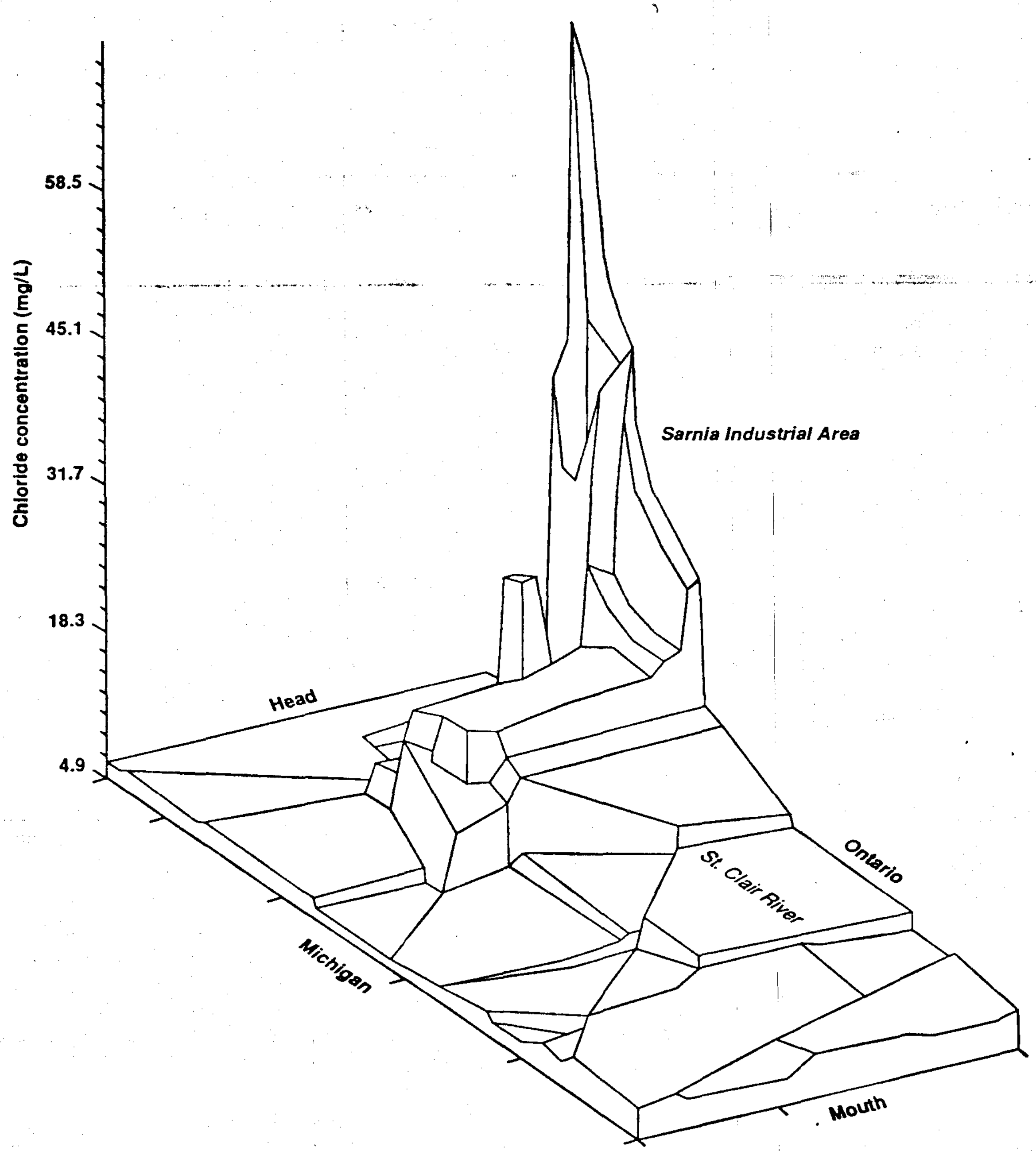


Table 6.8 **Annual means, ranges and number of samples for chloride in raw (ambient water quality) water samples taken at 3 water intakes from 1985 through 1988. Values are reported in mg/L.**

LOCATION	1985[1]	1986[2]	1988[3]
Lambton	4.90 4.8 - 5.0 (2)	5.89 5.0 - 6.5 (9)	6.38 5.7 - 7.5 (12)
Walpole Island	8.65 8.0 - 8.8 (4)	9.38 8.5 - 10.5 (4)	9.29 8.2 - 10.6 (15)
Wallaceburg	13.11 6.6 - 30.8 (8)	NA	10.02 8.1 - 11.4 (14)

NA-not available
1 OMOE 1985 Drinking Water Survey.
2 OMOE 1986 Drinking Water Surveillance Program.
3 OMOE 1988 Drinking Water Surveillance Program.

6.3.1.8 Bacteria

Some bacteria, virus, protozoa, worms and fungi are pathogens which are found in water and which may cause communicable diseases such as bacillary and amoebic dysentery, cholera, typhoid and paratyphoid fever, bacterial gastroenteritis, infectious hepatitis and others (McNeely et al. 1979). The primary origin of the pathogens in natural water include inadequately treated municipal wastewater and runoff from urban areas, private septic systems, farm lands, animal feed lots and contaminated soils. Human contact and disease transmission may occur through direct exposure via swimming or drinking or indirectly via food processing or cleaning.

Normal intestinal bacteria are used as indicators of the degree of pollution by pathogens. Fecal coliform bacteria, which are present in large numbers in faeces, are the most commonly measured organisms to determine water quality with respect to the protection of humans from water-borne communicable diseases.

The Ontario Provincial Water Quality Objective to protect humans from contracting a disease from pathogenic organisms is 100 fecal coliform organisms per 100 mL of sample. The Objective applies to swimming and bathing activities and is based on the geometric mean value for a series of water samples (OMOE 1984). The Michigan Surface WQS state that waters should not contain more than 200 fecal coliforms per 100 mL as a geometric mean for a series of 5 or more consecutive samples taken over a 30 day period (Chapter 4).

Table 6.9 lists fecal coliform data for eight beaches in Michigan. Although individual samples exceeded 200 organisms/100 mL, the Michigan WQS for fecal coliform requires a geometric mean of five consecutive samples collected within a 30 day period. The last five dates (July 24 through August 21) occur within a 30 day period. None of these beaches would likely exceed the Michigan WQS using the data from this time period (actual value shown as +200 organisms/100 mL not known).

Table 6.9 Fecal coliform densities (# organisms/100 mL) measured in individual samples at eight Michigan beaches during June, July and August of 1990 (County of St. Clair 1991). The Michigan WQS is 200 organisms/100 mL determined on the basis of a geometric mean of any series of five or more consecutive samples taken over not more than a 30 day period.

Date	Chrysler Park Marysville	St. Clair North	St. Clair South	St. Clair Voyager	Marine City Beach	Marine City Diving	Algonac State Park	Algonac City Boardwalk
06-12	46	10	-	NA	8	18	15	3
06-19	23	63	56	NA	48	61	49	34
06-26	146	20	8	+200	17	24	16	3
07-10	32	25	36	73	24	45	15	13
07-17	16	10	22	+200	6	+200	97	20
07-24	70	44	47	170	80	115	13	17
07-31	13	24	-	-	34	26	27	49
08-8	21	+200	15	+200	15	18	25	26
08-14	67	40	52	148	25	43	17	15
08-21	+200	28	24	NA	33	26	75	24

NA = data not collected.
- = invalid testing reported by lab.

Although there are little historical data on beach closures along the St. Clair River, swimming areas along the Ontario shore of the river were closed during 1990 (Lambton Health Unit 1991). The geometric mean of five samples collected on the same day are shown for five Ontario beaches in Table 6.10. The table also indicates dates during which the beaches were posted by the Lambton Health Unit. Geometric mean fecal coliform densities exceeded the PWQO (100 organisms/100 mL) at all five beaches for various periods during 1990.

Combined sewer overflows (CSOs) are a source of raw and/or inadequately treated sewage to the St. Clair River during and following rain events. Several CSO reports have been recorded from Michigan municipalities along the St. Clair River (Roy Schrameck, MDNR, pers. com.). The discharge of inadequately treated sewage is contrary to MDNR policy and prohibited in Michigan. As a result, all areas immediately downstream of Michigan CSOs are identified as impaired areas.

The 1986 MISA Pilot Site Investigation collected samples of bottom water and sediment for the determination of heterotrophic bacteria from 11 stations (OMOE 1990a). These included head and mouth stations on each of the Michigan and Ontario shores as well as stations located along the Ontario industrial complex from Esso Petroleum to immediately downstream of Talfourd Creek (stations 25U, 25C, 132, 203, 206, 211, 216, 18, 218, 214U and 214C on Figure 6.6 represent those stations sampled for heterotrophic bacteria).

Table 6.10 Geometric mean fecal coliform bacteria (# organisms/100 mL) for five beaches along the St. Clair River in Ontario during 1990. Means are based on five samples collected on the date indicated (Lambton Health Unit 1991). The PWQO for swimming and bathing activities is a geometric mean of fecal coliform bacteria in excess of 100 organisms/100 mL based on a series of consecutive samples.

Date	Seager	Lambton-Cundick Park	Brander Park	Centennial	Willow
06-5	27.0	94.4	52.1	30.6	30.9
06-11	102.4	96.7	36.8	25.7	66.1
06-18	129.0	266.1	124.5	15.2	47.0
06-25	29.9	325.6	41.1	268.1	46.8
06-28	NA	600.0*	NA	600.0	NA
07-3	15.2	114.9*	34.4	158.5*	89.8
07-9	55.3	246.1*	299.2	110.5*	34.7
07-11	NA	NA	218.9	159.4*	NA
07-16	59.1	290.5*	178.8*	146.4*	140.8
07-23	316.9	515.2*	188.1*	160.3*	296.9
07-25	403.5	NA	NA	NA	127.5
07-30	589.6*	600.0*	95.8*	428.9*	233.3
08-7	185.8*	600.0*	165.3	133.6*	128.1*
08-13	578.5*	600.0*	600.0	600.0*	600.0*
08-20	600.0*	566.5*	394.8*	600.0*	600.0*
08-27	505.8*	600.0*	439.9*	127.5*	130.0*

NA = data not collected.
* Beaches Posted by Lambton Health Unit during these dates.

Heterotrophic bacteria include all forms of bacteria which obtain their organic food from the environment. They also assist with the removal or breakdown of synthetic compounds as contributed from chemical and industrial effluents (OMOE 1990a). The native bacterial population may become overburdened by large discharges of synthetic organics which, in turn, may disrupt microbial degradation. Elevated total bacterial populations may adversely affect municipal drinking water supplies by contributing to taste and odour problems, biological fouling and the persistence of pathogens (OMOE 1990a).

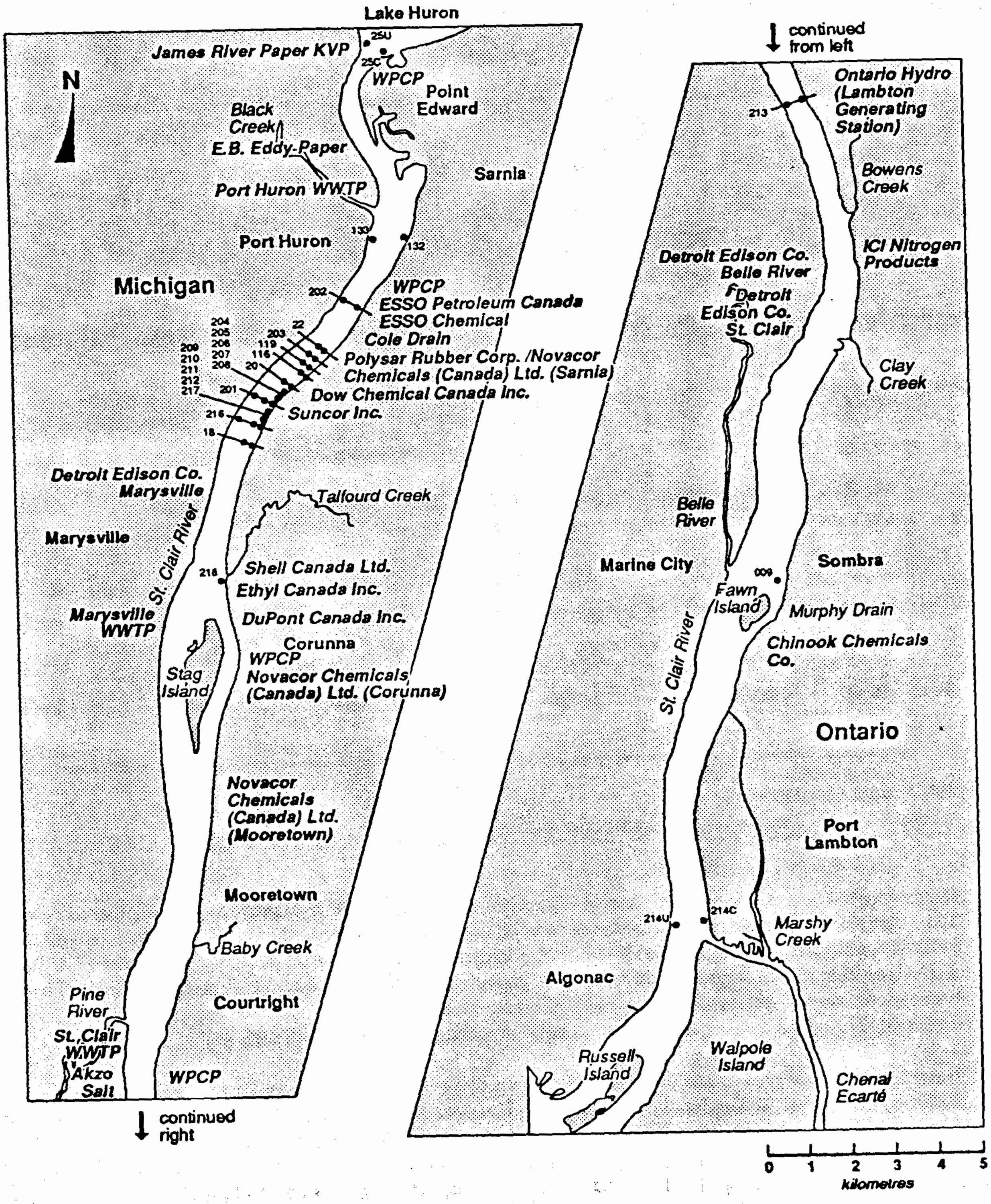
Heterotrophic bacterial counts from bottom waters along the Ontario shore increased from 2,200 organisms/mL at the head of the St. Clair River to 10,500 organisms/ml at the mouth. A maximum of 17,500 organisms/mL was recorded at a station immediately downstream of Talfourd Creek (OMOE 1990a). Sediment bacterial counts were typically an order of magnitude greater than bottom water (1,500 to 450,000 organisms/g wet weight for head and mouth, respectively). Bottom waters along the U.S. shore

Figure 6.6

St. Clair River Remedial Action Plan

Sample locations for the 1986 ambient water investigative water sampling study

(OMOE 1990a)



increased from 110 organisms/mL at the head to 13,000 organisms/mL at the mouth. Michigan sediment densities increased from 700 to 27,000 heterotrophs/g from head to mouth (OMOE 1990a).

Although there are no aquatic health guidelines or standards for heterotrophic bacteria in water or sediment, these data indicate that the Ontario shore of the St. Clair River has experienced bacterial contamination.

6.3.1.9 Mercury

Mercury (Hg) is known to be highly toxic. Although metallic mercury is relatively non-toxic, both organic and inorganic mercury salts have been shown to be highly toxic (Limno-Tech 1985). The presence of organic and inorganic mercury salts in water in excess of applicable guidelines pose a threat to the health of aquatic organisms. Toxicity testing of various aquatic species including *Daphnia magna*, and rainbow trout showed that methyl mercury concentrations in the range of 0.04 - 24 $\mu g/L$ caused acute and/or chronic effects (CCREM 1987). Metallic mercury is converted to its toxic organic form, methylmercury, by bacteria. Aquatic organisms readily accumulate methylmercury in their bodies either directly from the water or through the food web.

In 1973, reported mean ambient water values for mercury ranged from 4.6 $\mu g/L$ at the head of the river (in southern Lake Huron) to 2.4 $\mu g/L$ just north of Chenal Ecarte. At both locations, ambient water concentrations were higher along the Ontario shoreline (Limno-Tech 1985).

Mercury concentrations on both suspended solids and in unfiltered (whole) water samples collected from the St. Clair River in 1984 are summarized in Table 6.11 (Johnson and Kauss 1987). Sample locations are shown in Figure 6.7. More than 2,500 litres of river water were centrifuged in order to obtain sufficient particulate matter for analysis and reliable results.

Mercury concentrations for whole water (water plus suspended material) were below the Provincial Water Quality Objective (0.2 $\mu g/L$) for filtered water (i.e., sediment removed) throughout the entire length of the river. The Great Lakes Water Quality Agreement Objective (GLWQA) is also 0.2 $\mu g/L$.

The Michigan WQS (January 1991), Rule 57 Value for methylmercury [$Hg(CH_3)_2$] is 0.0013 $\mu g/L$. Methylmercury represents a small percentage of total mercury in water (CCREM 1987). The Michigan DNR, however, applies this value for total mercury based on the fact that biological effects caused by mercury are dominated by the organic forms, especially monomethyl mercury which is readily bioaccumulated (Minn. PCA 1985). Methylation of inorganic mercury occurs as a result of microbial activity in sediments, fish slime, water column particulates, and fish intestines. The mercury is, or may become, biologically available via methylation. Average mercury concentrations at the two locations which exceeded the detection limit in Table 6.11 exceeded Michigan WQS Rule 57 criterion. Because the detection limit is higher than the standard, it is not known whether the other locations were also in exceedence.

The Canadian Water Quality Guideline for total mercury is 0.1 $\mu g/L$ (CCREM 1987). This value was not exceeded in any of the whole water samples in Table 6.11.

Suspended solid concentrations are on a dry weight basis. Mercury levels in centrifuged particulates were dependent on the proximity of sampling stations to sources. Mercury in suspended solids was locally elevated (0.40 $\mu g/g$) in the industrial area south of Sarnia (Johnson and Kauss 1987). Suspended solids data suggests that Hg concentrations increase between the head and mouth of the river. The increases in the lower part of the river are particulary noticeable in the suspended solids data for the South Channel and Chenal Ecarte suggesting inputs along the Canadian shoreline travel downstream in plumes close to the shore as previously noted for conventional pollutants.

Figure 6.7

St. Clair River Remedial Action Plan

St. Clair River water sampling locations, 1984

Samples analyzed for heavy metals and organics in whole water and suspended solids

(Johnson and Kauss 1987)

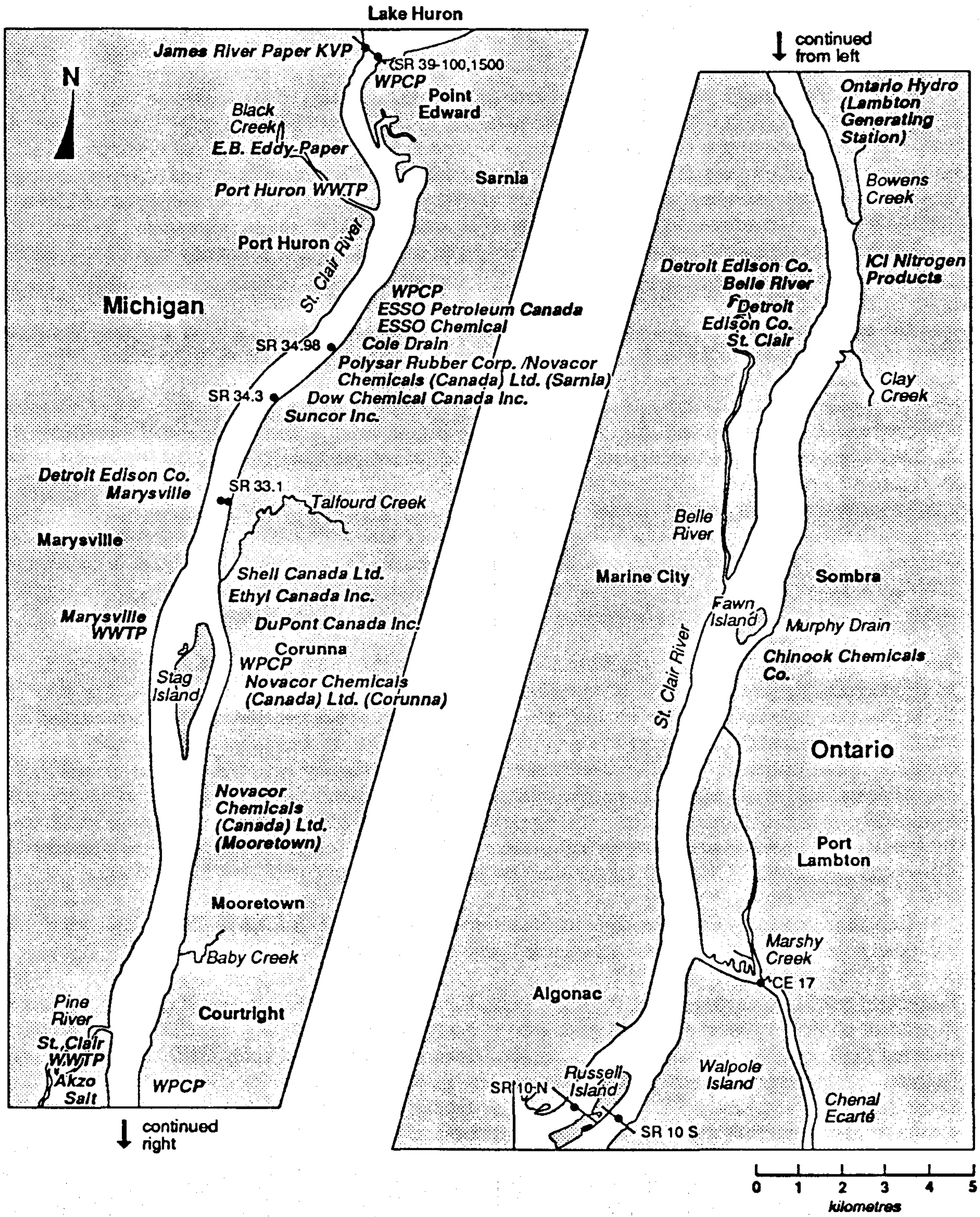


Table 6.11 Mean mercury concentrations in whole water and suspended solids in the St. Clair River for 1984. Values are mean and standard deviation of 4 surveys, unless otherwise stated (Johnson and Kauss 1987). The detection limit is 0.01 $\mu g/L$.

Sample Location	Mercury Concentration		Suspended Solids Amount (mg/L)
	Whole Water ($\mu g/L$)	Suspended Solids ($\mu g/g$)	
PWQO & GLWQA	0.2 (filtered)		
Michigan WQS Rule 57*	0.0013		
Canadian Guideline	0.1		
Head of River:			
SR39-100	<0.01	0.04 ± 0.01	4.3 ± 4.6
SR39-1500	<0.01	0.20 ± 0.3	7.8 ± 10.1
Near Industrial Outfalls SR33.1-SR34.98**	0.011	0.40 ± 0.5	7.8 ± 8.8
Mouth of River:			
North Channel SR10N	<0.01	0.09 ± 0.05	8.7 ± 3.6
South Channel SR10S	<0.01	0.27 ± 0.08	7.7 ± 2.4
Chenal Ecarte CE17	0.1	0.28 ± 0.14	26.1 ± 44.3

* January 1991 update.

** Mean of single samples taken during last survey at:
SR33.1 (20 + 200 m/65.6 + 656 ft offshore)
SR34.3 (20 m/65.6 ft offshore)
SR34.98 (60 m/196.8 ft offshore)

The results of the 1986 St. Clair River MISA Pilot Investigation (OMOE 1990a) investigative water quality survey for mercury are provided in Table 6.12. Figure 6.6 shows the location of transects and sampling locations. Mercury levels in whole water ranged from nondetectable to 0.03 $\mu g/L$ with 32.8 percent of samples (71 of 216) having concentrations either at or slightly above the detection level (0.01 $\mu g/L$). A total of 55 of the 'detects' were at the detection level and, thus, caution must be employed in interpreting the results. Samples were collected along 17 transects located throughout the river and included samples from both Ontario and Michigan waters (OMOE 1990a). Three samples had concentrations of 0.03 $\mu g/L$. Because these were measured in whole water, it is not known if they exceeded the PWQO of 0.02 $\mu g/L$ which is based on filtered samples. The three locations along the Ontario shore included two immediately downstream of Dow and one downstream of Suncor. All 71 of the samples having concentrations at or above detection exceeded the Michigan Surface WQS Rule 57 value. These were predominantly offshore and immediately downstream of the industrial waterfront south of Sarnia (Table 6.12 and Figure 6.6). However, the study also concluded "that while minor but consistent loadings of mercury from sources in the chemical valley were occurring, no significant differences were observed...between stations upstream and downstream from selected outfalls in the chemical valley" (OMOE 1990a).

Table 6.12 Mean, maximum and minimum concentrations of mercury ($\mu g/L$) for stations in the St. Clair River measured during the ambient investigative water sampling survey by OMOE (1990a). (ND = not detect. The detection limit is 0.01 $\mu g/L$.

Station	Distance from US shore (m)	n	mean	minimum	maximum
9	830	3	<0.01	ND	0.01
18	545	3	<0.01	ND	0.01
18	615	3	0.01	ND	0.01
18	635	6	0.01	ND	0.02
20	470	3	<0.01	ND	0.01
20	540	3	0.01	ND	0.02
20	550	12	0.01	ND	0.03
22	475	4	<0.01	ND	0.01
22	545	5	ND	ND	0.00
25	60	3	ND	ND	ND
25	330	3	<0.01	ND	0.01
116	570	3	<0.01	ND	0.01
116	590	6	<0.01	ND	0.01
119	375	6	ND	ND	ND
119	475	3	O.01	ND	0.01
132	0	3	ND	ND	ND
133	0	3	ND	ND	ND
201	125	3	<0.01	ND	0.01
201	560	3	ND	ND	ND
201	630	3	0.01	ND	0.02
201	650	6	0.01	ND	0.01
202	75	5	<0.01	ND	0.01
202	460	4	<0.01	ND	0.01
203	0	12	<0.01	ND	0.01
204	0	6	0.01	ND	0.03
205	0	6	<0.01	ND	0.01
206	0	6	ND	ND	ND
207	0	6	<0.01	ND	0.01
208	0	6	<0.01	ND	0.01
209	0	12	0.01	ND	0.02
210	0	6	0.01	ND	0.01
211	0	6	<0.01	ND	0.01
212	0	6	<0.01	ND	0.02
213	0	3	ND	ND	ND
213	467	3	ND	ND	ND
214	80	3	<0.01	ND	0.01
214	510	3	0.01	ND	0.02
216	75	6	<0.01	ND	0.01
216	500	3	ND	ND	ND
216	570	5	0.01	ND	0.01
216	590	6	0.10	ND	0.02
217	0	12	0.01	ND	0.03
218	0	3	<0.01	ND	0.01

The most recent information on mercury in whole water is from the 1988, OMOE Drinking Water Surveillance Program. Samples were taken monthly in 1988. Average annual mercury values in raw water samples at the Lambton (Sarnia), Walpole Island and Wallaceburg WTPs are 0.03, 0.02 and 0.01 µg/L, respectively. Ranges were: Lambton, below detection to 0.1 µg/L; Walpole Island, below detection to 0.1 µg/L; and Wallaceburg, below detection to 0.04 µg/L. The average annual concentrations decreased from head to mouth which is similar to the findings from the 1973 survey. The maximum and average values are all well below the PWQO, the GLWQA Objective and the Canadian Water Quality Guideline, however, all exceeded the Michigan WQS. Maximum values at Lambton (head of river) and Walpole Island equalled the Canadian Guideline.

Sampling during the 1980s show that mercury levels in whole water from the St. Clair River are much lower than those measured during the 1970s. Samples collected between 1986 and 1988 are generally below the detection level. Those above detection occur mostly in the area offshore and immediately downstream of the Sarnia industrial complex and exceed the Michigan WQS, Rule 57 value.

6.3.1.10 Lead

Lead (Pb) is considered a toxic substance to both aquatic life and human health. The presence of lead in the environment has been associated with automobile emissions, petroleum refining, automotive production and metal processing. The hardness of water will significantly impact on the toxicity of lead. Higher hardness levels result in less toxicity (Limno-Tech 1985).

Lead compounds are highly insoluble in water. Any soluble lead is quickly removed from solution by association with sediments and suspended solids such as organic matter, hydrous oxides and clays (CCREM 1987). Because of its high insolubility, historical data regarding lead in the St. Clair River deals only with its concentration in sediments.

An investigation of lead concentrations in whole water and suspended solids in the St. Clair River was carried out by Johnson and Kauss (1987; Table 6.13). All whole water samples showed concentrations of lead to be below the detection level (3 µg/L) which is greater than the Michigan Rule 57 level for lead, therefore a determination of exceedences of this standard cannot be made. However, mean concentrations of lead on the suspended solids fraction increased downstream along the Ontario shoreline (Table 6.13). The increased levels of lead on suspended solids for the South Channel and Chenal Ecarte samples but not for the North Channel samples suggest inputs of lead occur along the Canadian shoreline.

Results from the 1986 St. Clair River MISA Pilot Site Investigation (OMOE 1990a) showed that concentrations of lead measured at stations located throughout the river (Figure 6.6) were below the detection level for 215 of 216 samples. The only value above detection was 10.0 µg/L which was measured at a depth of 11.9 m (39 ft) near the Michigan shore immediately downstream of the outlet of the Black River. This value exceeds the Michigan WQS, Rule 57 value shown in Table 6.13 and may have exceeded the Provincial Water Quality Objective as well (PWQO for lead various depending on the hardness of the river).

The most recent information regarding concentrations of lead in water is from the 1988, OMOE Drinking Water Surveillance Program. Samples were taken monthly in 1988. Average lead values in raw water samples for the Lambton (Sarnia), Walpole Island and Wallaceburg were 0.181, 0.875 and 0.442 µg/L, respectively. Ranges were: Lambton, 0.03 to 0.50 µg/L; Walpole Island, 0.15 to 3.90 µg/L; and Wallaceburg, 0.25 to 0.66 µg/L. Although concentrations in downstream locations are elevated by up to 4 times the Lambton concentration, the PWQO, the GLWQA Objective (25 µg/L) and the Michigan WQS (January 1991), Rule 57 Value (2.88 µg/L, MDNR 1991) were exceeded by only one of the samples at Walpole Island.

Table 6.13 Mean lead concentrations in whole water and suspended solids in the St. Clair River. Samples were taken in 1984. Values are mean and standard deviation of 4 surveys, unless otherwise stated (Johnson and Kauss 1987).

Sample Location	Lead Concentration		Suspended Solids Amount (mg/L)
	Whole Water (μg/L)	Suspended Solids (μg/g)	
PWQO	5 - 25***		
GLWQA	25		
Michigan WQS Rule 57*	2.88		
Head of River:			
SR39-100	<3	26.0 $\pm$ 0.06	4.3 $\pm$ 4.6
SR39-1500	<3	19.8 $\pm$ 54	7.8 $\pm$ 10.1
Near Industrial Outfalls SR33.1-SR34.98**	<3	28.3 $\pm$ 9.1	7.8 $\pm$ 8.8
Mouth of River:			
North Channel SR10N	<3	23.0 $\pm$ 2.6	8.7 $\pm$ 3.6
South Channel SR10S	<3	40.0 $\pm$ 11.1	7.7 $\pm$ 2.4
Chenal Ecarte CE17	<3	41.8 $\pm$ 18.8	26.1 $\pm$ 44.3

* January 1991 update; Based on ambient water hardness of 100 mg/L
** Mean of single samples taken during last survey at:
SR33.1 (20 + 200 m/65.6 + 656 ft offshore)
SR34.3 (20 m/65.6 ft offshore)
SR34.98 (60 m/196.8 ft offshore)
*** Value depends on ambient water hardness (OMOE 1984).

6.3.1.11 Iron and Zinc

Zinc (Zn) contamination is usually associated with industrial discharges, especially the steel industry (McNeely et al. 1979). Iron (Fe) is also linked to the steel industry as well as to nonpoint source loadings. The toxic effects of zinc are not clearly understood. Iron is not considered toxic, however it does play an important ecological role in the aquatic environment as a phosphorus complexing agent (McNeely et al. 1979).

In the St. Clair River, zinc has not been considered as a parameter of concern, hence, historical information is not available. A 1976 OMOE survey monitored ambient water levels of total iron in the St. Clair River at 10 transect stations from below Sarnia, to Port Lambton. Total iron concentrations ranged from 20 to 440 μg/L (Limno-Tech 1985).

An investigation of iron and zinc concentrations in whole water and suspended solids in the St. Clair River was carried out in 1984 by Johnson and Kauss (1987) (Table 6.14, Figure 6.7). All whole water samples show iron concentrations to be consistent along the length of the river except in the Chenal Ecarte where Fe concentrations were twice the PWQO and the GLWQA Objective of 300 µg/L. All whole water samples showed concentrations of zinc to be at the detection limit. The PWQO and the GLWQA Objective for zinc in whole water is 30 µg/L. The Michigan WQS (January 1991), Rule 57 Value is 49.57 µg/L.

Table 6.14 Mean iron and zinc concentrations in whole water and suspended solids in the St. Clair River from samples collected in 1984. Values are mean and standard deviation of 4 surveys, unless otherwise stated. (Johnson and Kauss 1987).

Sample Location	Metal Concentration				Suspended Solids Amount (mg/L)
	Whole Water (µg/L)		Suspended Solids (µg/g)		
	Fe	Zn	Fe	Zn	
PWQO & GLWQA	300	30			
Michigan WQS Rule 57*	–	49.57			
Head of River:					
SR39-100	80 ± 90	1 ± 1	20,700 ± 60	86.1 ± 12.2	4.3 ± 4.6
SR39-1500	140 ± 20	2 ± 1	16,300 ± 4,800	76.3 ± 15.2	7.8 ± 10.1
Near Industrial Outfalls SR33.1-SR34.98**	140 ± 120	2 ± 1	19,000 + 1,800	109.3 ± 44.7	7.8 ± 8.8
Mouth of River:					
North Channel SR10N	130 ± 60	2 ± 1	19,000 ± 2,500	81.1 ± 5.6	8.7 ± 3.6
South Channel SR10S	100 ± 50	2 ± 2	16,000 ± 1,800	81.5 ± 19.2	7.7 ± 2.4
Chenal Ecarte CE17	600 ± 1000	3 ± 4	18,300 ± 2,800	83.0 ± 13.8	26.1 ± 44.3

* January 1991 update; based on ambient water hardness of 100 mg/L.

** Mean of single samples taken during last survey at:
SR33.1 (20 + 200 m/65.6 + 656 ft offshore)
SR34.3 (20 m/65.6 ft offshore)
SR34.98 (60 m. 196.8 ft offshore)

Zinc concentrations in centrifuged particulates were dependent on the proximity of sampling stations to sources, being locally elevated offshore of the industrial area south of Sarnia.

The most recent information measuring iron and zinc in water is from the 1988, OMOE Drinking Water Surveillance Program. Samples were taken monthly in 1988. Annual average iron values in raw water samples for the Lambton (Sarnia), Walpole Island and Wallaceburg WTPs were 53.2, 70.1 and 107.2 µg/L, respectively. Ranges were: Lambton, below detection to 210 µg/L; Walpole Island, 28 to 240 µg/L; and Wallaceburg, 31 to 300 µg/L. Annual average zinc concentrations at the water intakes were 2.24 µg/L at Lambton, 8.97 µg/L at Walpole Island, and 1.99 µg/L at Wallaceburg. Ranges were: Lambton, 0.29 to 5.80 µg/L; Walpole Island, 1.10 to 66.00 µg/L; and Wallaceburg 1.30 to 3.00.

Average annual concentrations tend to increase from the head (Lambton WTP) to the mouth of the river. This was most noticeable for iron. Average and maximum concentrations for iron in raw water at the WTPs did not exceed either the GLWQA or PWQ Objectives (300 µg/L). Average annual concentrations and all maximum values of zinc, with the exception of the maximum value at Walpole Island, were below the PWQ and GLWQA Objectives and the Michigan WQS. The maximum concentration which was recorded at Walpole in February, 1988 (66 µg/L) was more than twice the PWQO and the GLWQA Objective and slightly above the Michigan WQS.

6.3.1.12 Copper, Nickel, Cobalt, Cadmium and Chromium

Copper (Cu), nickel (Ni), cobalt (Co), cadmium (Cd) and chromium (Cr) are highly insoluble and tend to be more concentrated in sediment than in water. There is no historical information for the concentrations of Cu, Ni, Co, Cd and Cr in St. Clair River waters.

The most recent information measuring heavy metal content in water is from the OMOE Drinking Water Surveillance Program. Raw water samples were sampled monthly, during 1988. Average values, ranges and exceedences for Cu, Ni, Co, Cd, and Cr are shown in Table 6.15 along with the water quality objectives and standards.

Table 6.15 Copper, nickel, cobalt, cadmium and chromium mean annual concentrations and ranges (µg/L) in raw water at three Ontario water treatment plant intakes during 1988. Samples were collected approximately monthly at the Lambton (11 samples), Walpole Island (15 samples) and Wallaceburg (15) intakes (OMOE Drinking Water Surveillance Program, 1988 Annual Report). Sample locations are shown in Figure 6.3.

Location of Water Intake	Copper	Nickel	Cobalt	Cadmium	Chromium
Detection Limit	0.1	0.1	0.1	0.05	0.1
PWQO GLWQA Obj. Michigan WQS Rule 57*	5.0 5.0 10.72	25 25 33.4	- - -	0.2 0.2 0.41	100 50 48.1
Lambton	19.75 0.43-52.00 (45.5%)**	0.51*** ND-1.00	0.15 0.03-0.25	ND	0.99 0.22-5.60
Walpole Island	7.98 0.71-73 (20.0%)**	0.46*** ND-1.60	0.134 <0.02-0.29	0.068*** ND-0.15	2.42 0.47-5.60
Wallaceburg	2.61 1.8-3.3	0.74*** ND-2.90	0.166 0.07-0.26	ND	2.41 0.31-4.90

* January 1991 version; based on ambient water hardness of 100 mg/L.

** Percent of Samples exceeding the PWQO, GLWQA Objective and the Michigan Water Quality Standard, Rule 57 Value (all exceedences > 10.72 µg/L).

*** Non detects included as 0 µg/L for calculation of means.

Except for copper, all metal concentrations are well below the respective objectives or standards. Only chromium shows an increase in concentration down-river, increasing by 2.5 times its concentration at the head of the St. Clair River.

Average annual concentrations of copper are elevated at the head of the river relative to the mouth. Copper mean concentrations exceeded all three objectives/standards (Table 6.15) near the head of the river at the Lambton intake. Mean copper concentrations at the Walpole Island intake also exceeded the PWQO and the GLWQA Objectives. At the Lambton water intake (upstream of Sarnia), 45 percent of the samples taken during 1988 exceeded all three guidelines (PWQO, GLWQA and Michigan WQS) for copper (Table 6.15). Twenty percent of the samples exceeded all three guidelines at the Walpole Island intake. There were no exceedences at Wallaceburg.

The 1986 water intake Drinking Water Surveillance data for the Lambton Water Treatment Plant (WTP) also indicated high copper concentrations in raw water (1.0 to 260 μg/L for 6 samples). The cause of the high copper concentrations in water at the head of the Lambton WTP intake is not known and should be investigated.

The St. Clair River MISA Pilot Site Investigation investigative survey of 1986 measured cadmium along 17 transects throughout the river (Figure 6.6). Only 10 of 216 samples (4.6%) had detectable concentrations. These ranged from 0.1 to 0.7 μg/L with six samples exceeding the PWQO and the GLWQA Objective for cadmium (0.2 μg/L) and two exceeding the Michigan WQS (January 1991), Rule 57 Value (0.41 μg/L). All detectable concentrations were found along the Ontario shore immediately offshore of the Sarnia industrial complex. The furthest downstream location with detectable concentrations occurred immediately upstream of Fawn Island near Sombra. This location had the highest measured concentration (0.7 μg/L).

6.3.1.13 Organochlorine Pesticides

Chan and Kohli (1987) collected samples at 11 stations in the St. Clair River during four surveys in 1985. Samples were centrifuged to remove most of the suspended solids then analyzed for a total of 31 organochlorines including 17 pesticides. The concentration ranges for the pesticides are shown in Table 6.16. The sampling locations are shown in Figure 6.8. Most pesticides were below detection. Dieldrin, α-BHC, lindane, heptachlor epoxide and α-chlordane were the only pesticides detected throughout the St. Clair River. Pesticide compounds such as chlordane, endosulfans, heptachlor, τ-Chlordane, aldrin and DDT were either not detected or detected in only a few samples (Table 6.16).

Pesticide concentrations were fairly uniform throughout the river. Downstream samples were only slightly higher than those at the head of the river (Stations SC1 and SC2) and there was little or no spatial variation in samples taken from a cross-river transect at Port Lambton (Stations SC3 through SC8). The data would seem to indicate that there are no significant sources for these pesticides along the St. Clair River. Long-range transport was identified by Chan et al. (1986) as the likely mechanism for this "low-level" widespread contamination.

Concentrations of each pesticide were at least an order of magnitude below their respective PWQO and GLWQA Objectives. The only guideline exceedences were for dieldrin which exceeded the Michigan WQS (January 1991), Rule 57 Value of 0.0000315 μg/L (0.0315 ng/L) at every station on every occasion except the October 17th sample at Station SC2 (Table 6.16).

6.3.1.14 Polychlorinated Biphenyls (PCBs)

PCB contamination of the St. Clair River was discovered in the early 1970s and major sources were identified along the Canadian shore, near Sarnia. Spatial trends of PCB distribution in the river have

Table 6.16 Concentration ranges (ng/L[1]) for pesticides, hexachlorobenzene (HCB), hexachlorobutadiene (HCBD), octachlorostyrene (OCS) and PCBs at eleven stations in the St. Clair River sampled during in 1985 (Aug. 7, Aug. 27, Sept. 23 and Oct. 17) (Chan and Kohli 1987). Sample station locations are shown in Figure 6.8.

Parameter	Station										
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11
α-BHC	1.260-4.025	ND -3.350	2.485-5.025	2.175-5.475	1.925-5.475	2.975-5.000	3.000-7.200	1.800-6.875	2.700-6.450	2.443-6.650	2.178-5.725
Lindane	0.273-0.660	ND -0.478	0.400-0.883	0.350-0.773	0.425-0.807	0.500-0.638	0.455-0.950	0.445-1.015	0.463-1.010	0.525-0.830	0.368-0.853
Heptachlor-epoxide	0.068-0.127	ND -0.110	0.064-0.130	0.073-0.094	0.084-0.108	0.073-0.111	0.063-0.143	0.092-0.168	0.080-0.117	0.088-0.105	0.071-0.250
γ-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND -0.022	ND
α-Chlordane	ND -0.041	ND	ND	ND -0.018	ND	ND -0.019	ND	ND -0.035	ND -0.025	ND -0.030	ND -0.059
p,p'-DDE	ND -0.067	ND -0.030	ND	ND -0.036	ND -0.030	ND -0.033	ND	ND -0.020	ND -0.020	ND -0.023	ND -0.022
Dieldrin	0.165-0.273	ND -0.278	0.193-0.310	0.185-1.160	0.227-0.300	0.190-0.265	0.160-0.273	0.258-0.415	0.228-0.275	0.228-0.300	0.198-0.300
Total PCB	1.500-3.525	ND -2.080	1.000-1.845	0.975-2.145	0.793-1.725	1.125-1.478	0.885-1.800	1.058-1.218	0.925-1.958	1.098-1.913	0.685-1.648
HCBD	0.005-0.015	ND -0.009	1.800-4.975	1.300-8.025	0.450-2.243	0.075-0.588	0.017-0.130	0.014-0.035	1.400-10.650	0.019-0.191	0.450-2.368
OCS	ND	ND	0.028-0.063	0.012-0.080	ND -0.018	ND	ND	ND	0.015-0.085	ND	ND -0.019
HCB	0.014-0.024	ND -0.019	0.525-1.628	0.275-1.295	0.095-0.343	0.040-0.117	0.025-0.040	ND -0.028	0.350-2.115	0.025-0.075	0.093-0.545

[1] Values are shown as ng/L due to the low concentrations of pesticide compounds; move the decimal three places to the left in order to compare with other Tables in this section for which data are shown in μg/L.

Note: Heptachlor, Aldrin, α-Endosulfan, Endrin, o,p'-DDT, p,p'-TDP, p,p'-DDT, ß-Endosulfan, Mirex and Methoxychlor were not detected at any stations during all four surveys.

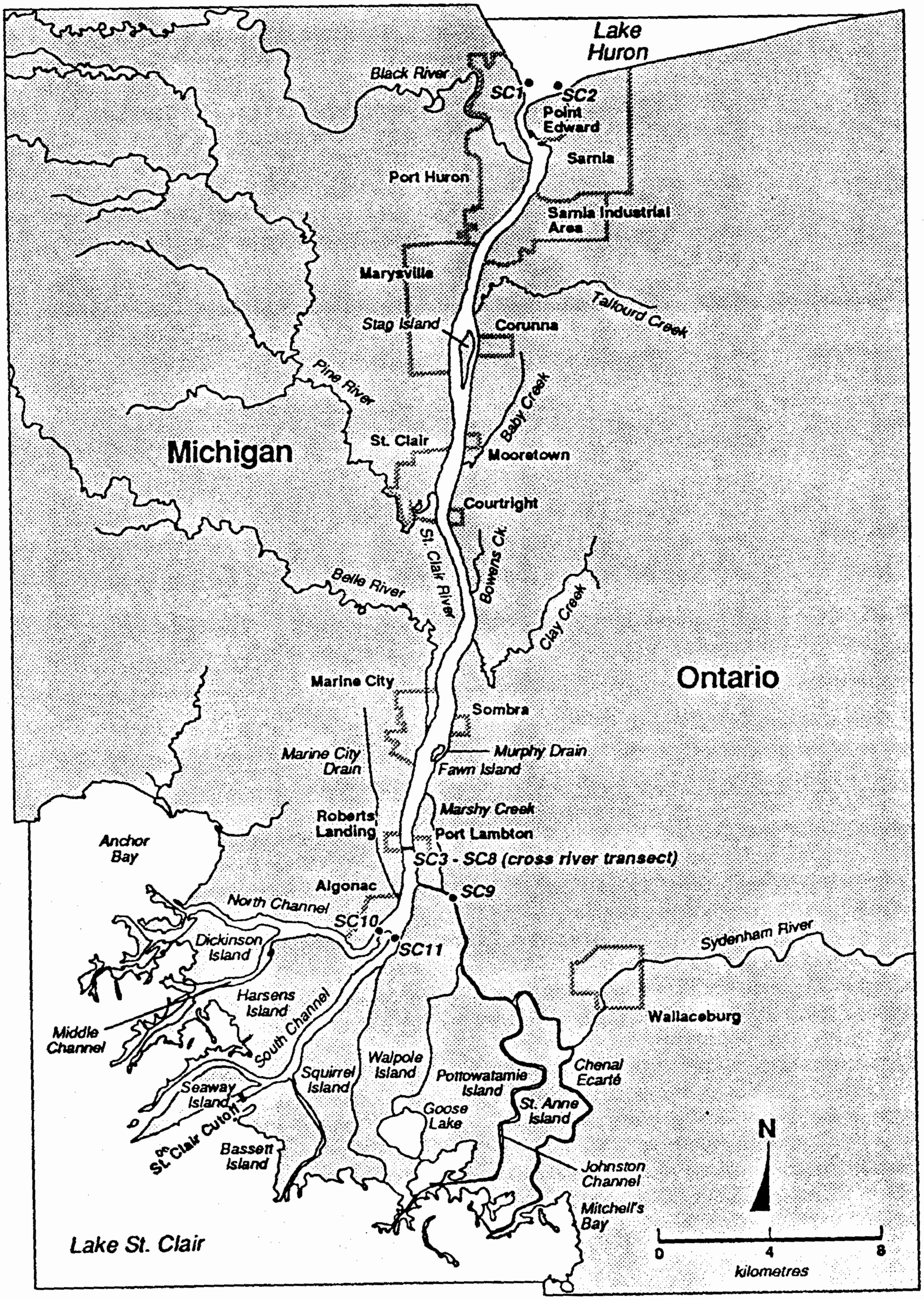
ND - below detection limit.

Figure 6.8

St. Clair River Remedial Action Plan

Location of the eleven sampling stations during 1985

(Chan and Kohli, 1987)



generally mirrored the sources (Limno-Tech 1985). Limited data shows some decline in PCB concentrations between 1975 and 1978 (Limno-Tech 1985).

Whole water (not filtered) and suspended solids from the St. Clair River were analyzed for total PCBs, octachlorostyrene and hexachlorobenzene by Johnson and Kauss (1987). Sampling locations are shown in Figure 6.7. Samples were collected during four surveys at stations located at the head of the river (SR 39-100 and 39-1500) and downstream in the Chenal Ecarte (CE 17) and North and South Channels (SR 10N, SR 10S). Additional samples were taken at 20 + 200 m (65.6 + 656 ft) (SR 33.1), 20 m (65.6 ft) (SR 34.3) and 60 m (196.8 ft) (SR 34.98) offshore below outfalls during one survey only. The data for suspended solids are summarized in Table 6.17 . All three parameters were below detection in whole water.

Table 6.17 Concentrations of total PCBs, hexachlorobenzene (HCB) and octachlorostyrene (OCS) on suspended solids in the St. Clair River (Johnson and Kauss 1987). Data presented as means, ranges, standard deviations or maximum value as indicated in footnote. Sample station locations are shown in Figure 6.7.

Station	n	PCBs (µg/g)	HCB (µg/g)	OCS (µg/g)	SUSPENDED SOLIDS (mg/L)
SR39-100	4	ND	ND	ND	4.3 4.6
SR39-1500	4	ND	<0.0010 (0.1130)	<0.0010 (0.0040)	7.8 10.1
SR33.1, SR34.3 & SR34.98	3	0.0413 0.0473	0.535 0.880	0.0016 (0.0008)	7.8 8.8
SR10N	4	<0.0200 (0.0250)	0.0488 (0.0160-0.0760)	0.0040-0.0840	8.7 3.6
SR10S	4	<0.0200 (0.0800)	0.1230 (ND-0.1900)	<0.0010-0.0840	7.7 2.4
CE17	4	ND	0.0380 (0.0050-0.0610)	0.0220 (0.0080-0.0410)	26.1 44.3

ND - below detection (0.02 µg/L for PCBs and 0.001 for HCB and OCS)
Note: standard deviation indicated by ' ' where three or more samples were above detection, range provided for only 2 detects, maximum value provided in if only 1 detection.

Mean total PCB levels in centrifuged particulates were elevated in the samples collected near the outfalls (0.0413 µg/g) in the industrial area south of Sarnia (Table 6.17). Total PCB concentrations in suspended sediments at both the head of the St. Clair River and in the Chenal Ecarte were below detection. Two of the three samples collected in each channel (SR10S and 10N) were below the detection limit, however, individual samples at each location had concentrations in the same range as the concentrations measured downstream of the outfalls (Table 6.17). The Johnson and Kauss (1987) data suggest there may be some inputs of PCBs along the Sarnia industrial complex based on detectable concentrations occurring on suspended solids at all three stations near outfalls.

PCB concentrations in filtered samples from the St. Clair River were measured during 1985 by Chan and Kohli (1987). Samples were collected during four surveys (Table 6.16). There were a total of 11 sampling stations in the river including two at the head (Ontario and Michigan stations), six along a transect across the river at Port Lambton and three in the delta (Figure 6.8). The distribution of PCBs was fairly uniform at all stations in the river with no marked spatial variation between head and mouth samples or cross-river at Port Lambton (Chan and Kohli 1987). The mean concentration was 0.0012 µg/L with a range of below detection to 0.00353 µg/L (Table 6.16). The sample station at the head of the river on the Michigan side (Station

SC1) consistently showed a higher concentration, about twice that measured on the Ontario side. The authors attributed this to inputs from sources upstream of the St. Clair River.

All PCB concentrations measured by Chan and Kohli (1987) were below the PWQO of 1 μg/L. The Canadian Water Quality Guideline for the protection of freshwater aquatic life (0.001 μg/L) was slightly exceeded by the mean concentration of total PCBs. It was also exceeded by the maximum concentrations at all 11 stations and by the minimum concentrations at 4 of the stations (Table 6.16). The Michigan WQS (January 1991), Rule 57 Value for total PCBs (0.00002 μg/L) was exceeded at all locations in the river, including both head and mouth locations, on all 4 sampling dates except possibly the nondetectable value at Station SC-2. The detection limit (0.0002 μg/L; C.H. Chan, Environment Canada, pers. com.) was higher than the Michigan WQS, thus it is not known if the minimum value at this station exceeded the standard.

6.3.1.15 Industrial Chlorinated Organics

Since 1984, there have been several studies measuring the concentrations and distribution of chlorinated industrial organics in the St. Clair River. The compounds most commonly investigated are hexachloroethane, hexachlorobutadiene, pentachlorobenzene, hexachlorobenzene and octachlorostyrene.

Johnson and Kauss 1984 Survey

Whole water samples analyzed by Johnson and Kauss (1987) in 1984 showed the concentrations of hexachlorobenzene and octachlorostyrene were at the method detection limit (0.001 μg/L). Concentrations of these contaminants in suspended solids from locations at and downstream of point sources were elevated relative to samples collected upstream, indicating that they were present in the whole water samples, but at levels which were too low to quantify (i.e., below detection). The suspended solids results (Table 6.17) show increases of at least one to two orders of magnitude between the head and mouth of the river. These data indicate that substantial inputs of hexachlorobenzene and, to a lesser degree, octachlorostyrene occur along the Sarnia industrial waterfront.

Oliver and Kaiser 1985 Survey

During April 1985, large volume water samples and associated suspended sediments were collected at 21 locations (Figure 6.9) by Oliver and Kaiser (1986). Samples were collected at mid-depth and centrifuged to remove the suspended solids. All five contaminants, hexachloroethane, hexachlorobutadiene, pentachlorobenzene, hexachlorobenzene and octachlorostyrene were detected in most samples and all exhibited increases along the river (Table 6.18). "Dramatic increases in these contaminant concentrations occurred after the Township Ditch [Cole Drain], with the highest values observed near Dow". Peak concentrations in whole water were: hexachloroethane, 1.7; hexachlorobutadiene, 0.15; pentachlorobenzene, 0.003; hexachlorobenzene, 0.087; and octachlorostyrene, 0.0072 μg/L (Table 6.18). Maximum concentrations on suspended sediment were: hexachloroethane, 0.53; hexachlorobutadiene, 24; pentachlorobenzene, 0.6; hexachlorobenzene, 40; and octachlorostyrene, 3.1 μg/g. Elevated concentrations persist for at least 25 km (15.5 mi) downstream from Station C-5 through C-16 (Figure 6.9) and, as no other sources of these chemicals were apparent, the elevated downstream concentrations indicated an effluent plume which hugged the Canadian shoreline for a considerable distance. A slight increase in concentration is apparent for all compounds, with the exception of Hexachlorobenzene, along the 3 km between the two stations on the U.S. side of the river, U-2 and U-3 (Oliver and Kaiser 1986).

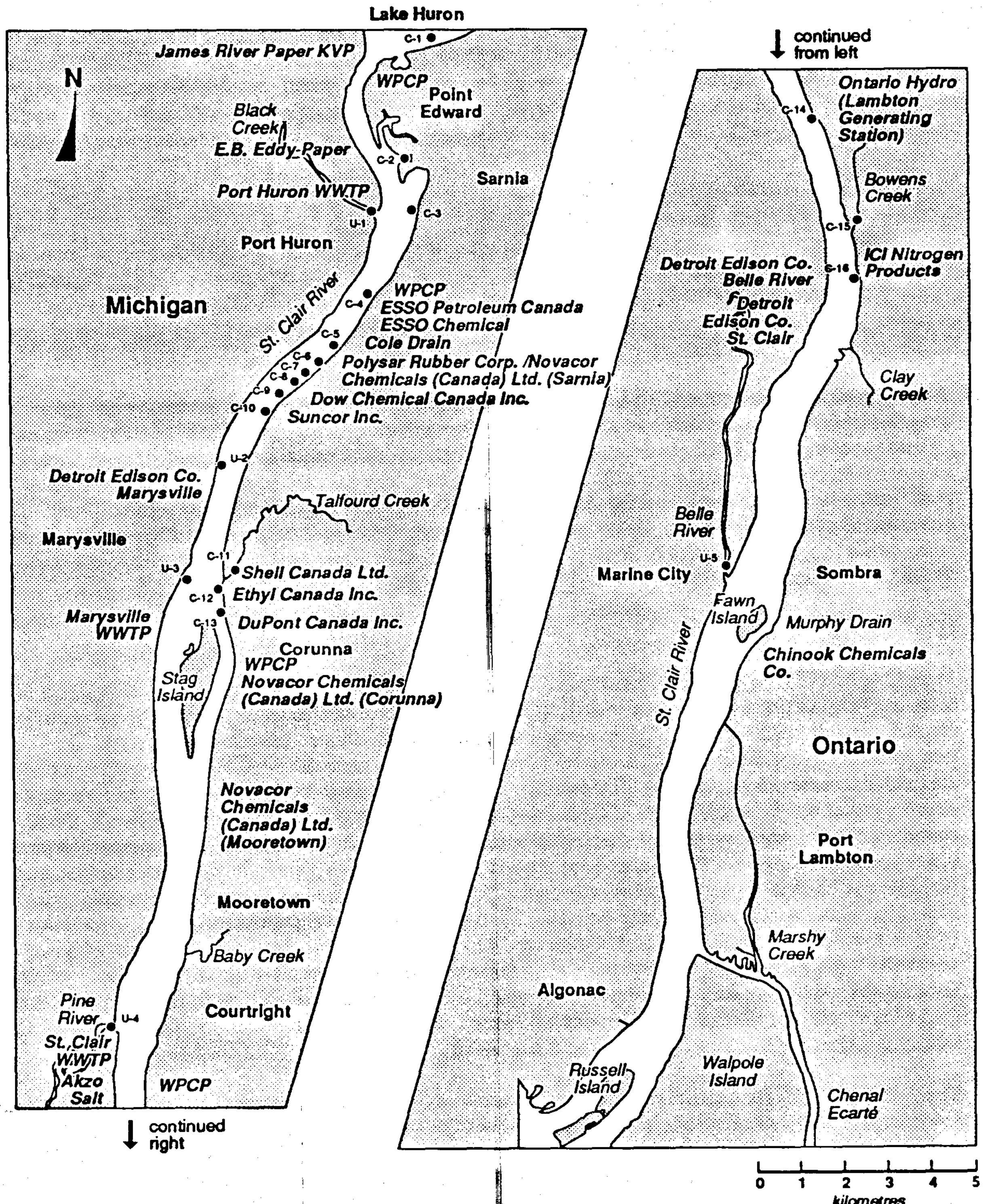
There is no PWQO for hexachlorobutadiene, however, the 1985 peak concentrations on the Ontario side (Stations C-7 and C-8) exceeded the Canadian Water Quality Guideline for Freshwater Aquatic Life (0.1 μg/L, CCREM 1987). The hexachlorobenzene PWQO of 0.0065 μg/L and the Michigan WQS (January 1991), Rule 57 Value of 0.0018 μg/L (MDNR 1991) were exceeded in whole water samples from six stations downstream of the Cole Drain (Stations C-7 through C-13). The Michigan WQS for

Figure 6.9

St. Clair River Remedial Action Plan

Location map of sampling stations for measurement of chlorinated organics in nearshore waters and tributaries of the St. Clair River in 1985

(from Oliver and Kaiser 1986)



hexachlorobenzene was also exceeded by two additional stations (Stations C-14 and C-16) on the Ontario side of the river. Although there is no PWQO for octachlorostyrene, the OMOE has established an interim Water Quality Advisory guideline for octachlorostyrene of 0.0001 μg/L (OMOE 1990a). This interim guideline was also exceeded at eight stations in the river (Stations C-4, C-5, C-7 to C-10, C-12 and C-16) downstream of the Sarnia Water Pollution Control Plant (WPCP).

Table 6.18 Contaminant Concentrations in whole water (μg/L) for the St. Clair River nearshore and tributary samples (Oliver and Kaiser 1986). Sample locations are shown in Figure 6.9.

Compound	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8
Hexachloroethane	0.00094	0.00220	0.00270	0.00500	0.00180	0.00470	0.53000	1.70000
Hexachlorobutadiene	0.00025	0.00064	0.00045	0.00110	0.00440	0.00750	0.11400	0.15000
Pentachlorobenzene	0.00003	0.00027	0.00005	0.00009	0.00012	0.00012	0.00120	0.00300
Hexachlorobenzene	0.00059	0.00053	0.00030	0.00170	0.00067	0.00033	0.08700	0.06100
Octachlorostyrene	0.00003	0.00008	0.00002	0.00013	0.00027	0.00003	0.00720	0.00050

Compound	C-9	C-10	C-12	C-13	C-14	C-16	U-2	U-3
Hexachloroethane	0.11000	0.08500	0.06700	0.01700	0.03800	0.01400	0.00280	0.00440
Hexachlorobutadiene	0.06000	0.00940	0.00370	0.00240	0.00740	0.00270	0.00028	0.00031
Pentachlorobenzene	0.00036	0.00046	0.00120	0.00034	0.00016	0.00014	0.00005	0.00007
Hexachlorobenzene	0.03100	0.01000	0.00760	0.00900	0.00220	0.00230	0.00036	0.00031
Octachlorostyrene	0.00250	0.00075	0.00034	0.00054	0.00019	0.00011	ND	0.00004

Tributaries

Compound	C-11 Talfourd C.	C-15 Bowens C.	U-1 Black R.	U-4 Pine R.	U-5 Belle R.
Hexachloroethane	0.04100	0.02700	0.00100	0.02000	0.00002
Hexachlorobutadiene	0.05900	0.00480	0.00017	0.00130	0.00026
Pentachlorobenzene	0.00038	0.00022	0.00004	0.00008	0.00002
Hexachlorobenzene	0.03400	0.00280	0.00008	0.00079	0.00074
Octachlorostyrene	0.00160	0.00036	0.00001	0.00005	0.00002

Two tributaries on the Canadian side of the river, Talfourd and Bowens Creeks, contained measurable concentrations of all five contaminants in approximately the same ratios as the river samples (Table 6.18, Oliver and Kaiser 1986). The highest values were found in Talfourd Creek which flows through a portion of Sarnia's industrial area. The reported concentrations of hexachlorobenzene for Talfourd Creek (0.034 μg/L) exceeded both the PWQO (0.0065 μg/L) and the Michigan WQS, Rule 57 (January 1991) (0.0018 μg/L) values. In Bowens Creek, hexachlorobenzene exceeded the Michigan WQS but not the PWQO. The OMOE interim water quality advisory for octachlorostyrene (0.0001 μg/L) was exceeded at the mouths of both Talfourd and Bowens Creeks. Of the Michigan tributaries, the highest concentrations were found in the

Pine River which flows into the St. Clair River approximately 18 km (11.2 mi) downstream of Sarnia (Table 6.18). However, concentrations of all five parameters in the Pine River were lower than in either of the two Ontario tributaries sampled and did not exceed the PWQO or Michigan WQS for hexachlorobenzene nor the interim OMOE advisory for octachlorostyrene.

Chan and Kohli 1985 Survey

From August through October 1985, large volume water samples (<40 L) were collected by Chan and Kohli (1987) from eleven stations including the head of the St. Clair River, at a transect at Port Lambton and at the river's mouth on the north and south channels and at Chenal Ecarte (Figure 6.8). The data are shown in Table 6.16. Results were similar to those of Oliver and Kaiser (1986). Concentrations of hexachlorobenzene and pentachlorobenzene at Port Lambton were relatively higher than background stations, and these levels declined rapidly to near the detection limit towards the Michigan shore (Table 6.16). For example, concentrations of hexachlorobenzene close to the Ontario shore ranged from 0.000525 to 0.001628 µg/L and tapered off to <0.000025 µg/L (detection limit). Farther downstream, elevated concentrations of hexachlorobenzene were confined to Chenal Ecarte (0.00035 to 0.002115 µg/L) and the South Channel (0.000093 to 0.000545 µg/L). The PWQO for hexachlorobenzene (0.0065 µg/L) was not exceeded, however, the Michigan WQS (January 1991), Rule 57 Value (0.0018 µg/L) was exceeded by the maximum value measured for the Chenal Ecarte.

The concentration of hexachlorobutadiene at the head of the St. Clair River was barely quantifiable (<0.00001 µg/L, Table 6.16). At Port Lambton, however, levels of this parameter were in the range of 0.003 to 0.009 µg/L. This plume is confined to within 300 m (984 ft) of the Canadian shoreline and continued downstream into the Chenal Ecarte and South Channel where maximum values were 0.01065 and 0.002368 µg/L, respectively. The same pattern was evident with octachlorostyrene, although the levels of this chemical were almost two orders of magnitude lower. Because hexachlorobutadiene is virtually undetectable in Lake Huron, the elevated levels downstream in the St. Clair River represent a localized input downstream from Sarnia (Chan and Kohli 1987).

The hexachlorobutadiene Canadian Water Quality Guideline for Freshwater Aquatic Life (0.1 µg/L) was not exceeded in ambient waters close to the Ontario shore at Port Lambton and Chenal Ecarte.

Concentrations of octachlorostyrene ranged from 0.007 to 0.085 µg/L with the highest values found closest to the Ontario shoreline at Port Lambton (Table 6.16). The OMOE tentative guideline of 0.0001 µg/L for octachlorostyrene was exceeded by all values in the 1985 Chan and Kohli (1987) survey. This guideline is based on limited toxicological data. It was developed for comparative purposes only in the absence of other criteria.

1986 OMOE MISA Pilot Site Investigation

The 1986 St. Clair River MISA Pilot Site Investigation focused on five chlorinated organic compounds, namely hexachlorobenzene, hexachlorobutadiene, hexachloroethane, octachlorostyrene, and 2,4,5-trichlorotoluene. These compounds were selected because they are intermediate or end products from organic chemical manufacturing processes and they tend to bioaccumulate in aquatic organisms (OMOE 1990a).

Two ambient water quality monitoring surveys were done, each defined by the type of sampling: (1) Centrifugation - large volume water samples were centrifuged in order to separate the aqueous and suspended sediment portions; and (2) Investigative Water Sampling - both surface and bottom whole water samples.

(1) Centrifugation

Ambient water centrifuging sample locations are shown on Figure 6.10. Large volume water samples were collected in May, June and October, 1986. At the point of discharge, some organic compounds were found to be almost entirely sorbed to suspended solids, whereas others were primarily in the dissolved form.

Detectable levels of hexachlorobenzene, hexachlorobutadiene and hexachloroethane were observed in water samples from the Cole Drain downstream to the mouth of the St. Clair River. The measured concentrations of these substances adjacent to outfalls were two to three orders of magnitude higher than background levels upstream from the Sarnia industrial complex. These measurements showed a high degree of variability which corresponded to the observed variability in effluent loads which were also sampled during the study (OMOE 1990a). Chemical concentrations in the river were observed to drop with increasing distance from the outfalls. For example, hexachlorobenzene ambient water concentrations at the Chenal Ecarte were approximately one order of magnitude lower than those adjacent to outfalls.

Centrifuged samples revealed that at the point of discharge, hexachlorobenzene, octachlorostyrene and hexachlorobutadiene were almost entirely sorbed to suspended solids. "With increasing distance from the outfall, the fraction of chemical associated with suspended sediments was reduced substantially and the fraction of dissolved chemical was increased. This indicates that, in the receiving-waters, chemicals associated with suspended matter either tend to desorb and thus become available for uptake in aquatic organisms or that a dilution effect from clean suspended solids may occur. The centrifuging results indicate that by the time the discharge reaches the Suncor property, most of the contaminants are dissolved" (OMOE 1990a).

Water samples collected during May and October 1986 indicated a relatively uniform vertical distribution for most contaminants based on a comparison of surface and bottom water samples. Concentrations of the least soluble substances, hexachlorobenzene and octachlorostyrene, tended to be higher at the bottom (i.e., near the sediments) and lower near the surface. A possible explanation for this behaviour is that hexachlorobenzene and octachlorostyrene were predominantly associated with particulate matter, which tend to settle to the bottom.

(2) Investigative Water Sampling

Several monitoring strategies were employed to document the spatial distribution of selected parameters throughout the St. Clair River. The survey was set up in order to determine the lateral and downstream effects of point sources and to identify the zone of potential impact. In addition, the extent of contamination at the water-sediment interface might provide more information about contaminant transport and release in this thin microlayer (OMOE 1990a).

Grab sampling of surface and bottom water was carried out at 43 stations and sediments were sampled at 50 percent of these locations. The stations were selected from the headwaters to the delta (Figure 6.6) and situated 10, 30 and/or 100 m (32.8, 65.6 and/or 328 ft) from the Ontario shoreline. Several stations were also situated adjacent to the Michigan shoreline. Sampling was carried out in May, July and October, 1986.

The spatial distribution of some industrial organic compounds was similar to that of conductivity and chloride (Figures 6.4 and 6.5, respectively). One difference being the decrease observed for the latter two parameters between the Cole Drain and the Dow Chemical outfall, which was less evident for organic compounds. This was likely due to continuous elevated inputs from the Dow 1st Street complex (OMOE 1990a).

Table 6.19 provides a summary of samples above detection limits by sampling cruise for selected parameters. A summary of these criteria for a more complete list of parameters is provided in Table 6.20.

Figure 6.10

St. Clair River Remedial Action Plan

The location of ambient water centrifuging sample stations for the 1986 St. Clair River MISA Pilot Site Investigation

(OMOE 1990a)

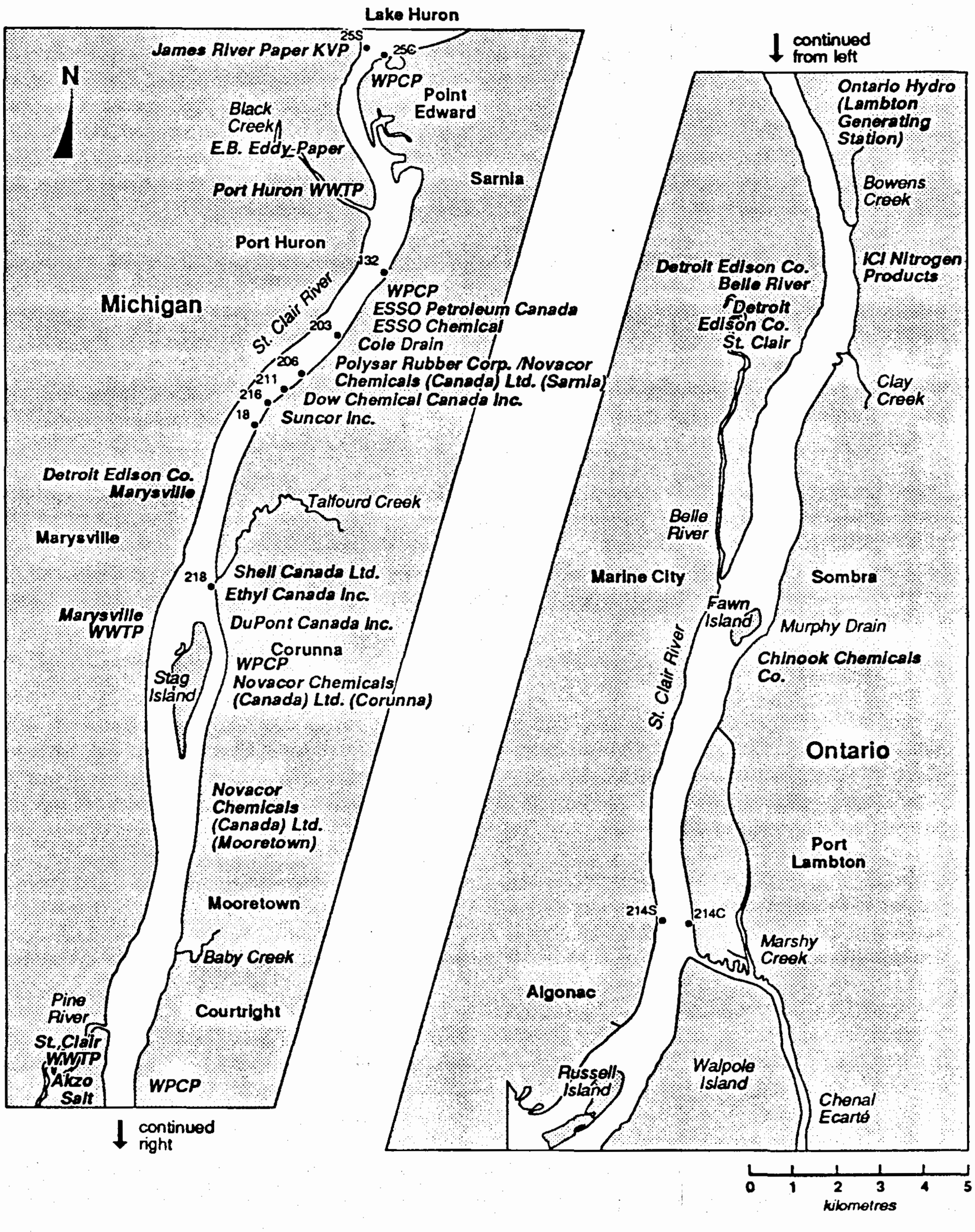


Table 6.19 Samples exceeding water quality criteria for selected parameters from the 1986 investigative water sampling survey (OMOE 1990a).

Percent > Water Quality Criteria (WQC)				
Parameter	Criteria (µg/L)	May (no. of samples)	July (no.of samples)	October (no. of samples)
Hexachlorobenzene	0.0065[1] 0.0018[2]	9.4 (9/85) 25.9 (22/85)	14.9 (14/94) 37.2 (35/94)	9.8 (9/92) 28.3 (26/92)
Hexachloroethane	13[2]	0 (0/85)	0 (0/94)	0 (0/92)
Hexachlorobutadiene	0.1[3]	0 (0/85)	0 (0/94)	2.2 (2/92)
Octachlorostyrene	0.0001[4]		7.8 21/271	
Carbon Tetrachloride	20[2]	0 (0/94)	0 (0/95)	0 (0/93)
Tetrachloroethylene	260[3] 16[2]	0 (0/94) 0	0 (0/95) 0	0 (0/95) 0

[1] Provincial Water Quality Objective (OMOE 1984).
[2] Michigan Water Quality Standard, Rule 57 Value (January 1991).
[3] Canadian Council of Resource and Environment Ministers guideline for the protection of Aquatic Life (CCREM 1987).
[4] Ontario Ministry of the Environment, Water Quality Advisory (OMOE 1990a).

Hexachlorobenzene levels were determined in excess of the PWQO (0.0065 µg/L) and Michigan WQS (January 1991), Rule 57 Value (0.0018 µg/L) downstream of the Cole Drain outfall (max. 0.023 µg/L), and again at several stations downstream of the Dow 1st Street outfalls (max. 0.21 µg/L). Concentrations downstream of the Dow property line (1.1 km/0.7 mi) below the 1st Street Sewer complex) were not in violation of the objective (OMOE 1990a).

For comparison, hexachlorobenzene levels where higher in 1984, averaging 0.4 µg/L (7 samples) with a maximum concentration of 2.4 µg/L at a point 100 m (328 ft) downstream of the Dow 1st Street complex (OMOE 1990a). At a distance of 600 m (1,968 ft) downstream from this source, levels were still in excess of the PWQO (and Michigan WQS) by a factor of 100 indicating that simple dilution is not an appropriate alternative to treatment (OMOE 1990a). In November 1985, the peak concentration for hexachlorobenzene was 0.131 µg/L. The PWQO and Michigan WQS, Rule 57 Value for hexachlorobenzene was exceeded as far downstream as the head of Stag Island near Corunna (OMOE 1990a).

The Michigan WQS (January 1991), Rule 57 Value for hexachloroethane is 13 µg/L. The maximum concentration of this parameter (0.169 µg/L), which occurred just downstream of the Cole Drain, is well below the Michigan standard.

Table 6.20 **Frequency of samples in excess of method detection limits (MDL) and water quality criteria (WQC) during the 1986 OMOE investigative survey (OMOE 1990a).**

Parameter	MDL µg/L	WQC µg/L	%>MDL	%>WQC	n	min µg/L	max µg/L	$\bar{x}$ µg/L
Benzene	1.0	300[3] 60[2]	0	0 0	283	ND	ND	ND
Toluene	1.0	300[3] 100[2]	0	0 0	284	ND	ND	ND
Ethylbenzene	1.0	700[3] 30[2]	0	0 0	284	ND	ND	ND
Xylene - m, p	1.0	59[2] (total xylene)	0	0	284	ND	ND	ND
1,1,2-Trichloroethane	1.0	65[2]	2.8	0	284	ND	4	0.1
Xylene - O	1.0	N.A.	0	-	284	ND	ND	ND
Aldrin	0.001	0.001[1]	0	0	271	ND	ND	ND
Alpha - BHC	0.001	0.01[1]	95.6	0	271	ND	0.005	0.0025
Gamma - BHC	0.001	0.01[1]	16.2	0	271	ND	0.005	0.0004
Dieldrin	0.001	0.001[1] 0.0000315[2]	0.4	0.4 0.4	271	ND	0.002	0.00001
Heptachlor	0.001	0.02[2]	7.0	0	271	ND	0.007	0.0003
Carbon Tetrachloride	1.0	20[2]	25.5	0.4	282	ND	42.0	0.8[5]
Hexachlorobenzene	0.001	0.0065[1] 0.0018[2]	42.8	11.8 30.6	271	ND	0.210	0.0044
Tetrachloroethylene	1.0	260[3] 16[2]	32.8	0 1.4	284	ND	44.0	1.5
Hexachloroethane	0.001	13[2]	26.6	0	271	ND	0.169	0.0031
Octachlorostyrene	0.001	0.0001[4]	7.8	7.8	271	ND	0.020	0.0004
Pentachlorobenzene	0.001	0.03[3]	10.0	0	271	ND	0.013	0.0004
2,4,5-Trichlorotoluene	0.001	0.117[4]	3.7	0	271	ND	0.086	0.0012
1,2,3,4-Tetrachlorobenzene	0.001	0.1[3] 0.76[2]	3.3	0 0	271	ND	0.007	0.0001
1,2,4-Trichlorobenzene	0.001	0.5[3] 22.0[2]	3.3	0 0	271	ND	0.179	0.0017
Hexachlorobutadiene	0.001	0.1[3]	46.4	0.1	271	ND	0.116	0.0065

[1] -PWQO(OMOE 1984).
[2] -Michigan WQS, Rule 57 Value (January 1991).
[3] -CCREM Guideline for the protection of aquatic life (1987).
[4] -OMOE Water Quality Advisory (conservative number based on limited toxicological information.
[5] -max. and average for tetrachloroethylene have been corrected to proper units; Table 4.2.6 of OMOE (1990) shows these as ng/L while incorrectly indicating the units as µg/L.

Note: Value for 2,4,5-Trichlorotoluene has since been updated to 0.134 based on additional information (OMOE 1990a).

Concentrations of hexachlorobutadiene exceed the Canadian guideline (CCREM 1987) (0.1 μg/L) in two locations. Downstream of the Cole Drain, concentrations of this parameter ranged from 0.053 to 0.116 μg/L. Hexachlorobutadiene concentrations downstream of the Dow 1st Street Sewer complex were generally lower than at the Cole Drain, however there was one maximum value of 0.116 μg/L.

Octachlorostyrene is a highly persistent and bioaccumulative substance. The OMOE water quality advisory for this parameter (a tentative and highly conservative value based on limited toxicological information) was exceeded in approximately 8 percent of the water samples. Most of the exceedences occurred in the July sampling period (OMOE 1990a). The maximum octachlorostyrene concentrations were just downstream of the Cole Drain (0.017 μg/L) at Station 119 (Figure 6.6). However, the frequency of exceedences increased further downstream of the Dow and Suncor outfalls with a maximum value of 0.02 μg/L at station 209 (Figure 6.6). This would indicate the presence of additional sources. Due to the low solubility (hydrophobic) of octachlorostyrene, it is easily taken-up by biological organisms and passed along the food chain. No definitive criteria are available from OMOE or other agencies.

Water quality criteria for hexachloroethane and 2,4,5-trichlorotoluene were not exceeded (Table 6.20).

Dibenzo-p-dioxins and Dibenzofurans

Analysis of ambient water for chlorinated dibenzo-p-dioxins and dibenzofurans has not generally been undertaken in the St. Clair River AOC. The only data currently available are for samples collected at the Lambton, Walpole Island and Wallaceburg Water Treatment Plants during 1985 and 1986 (OMOE Drinking Water Surveillance Program, January 1986 update report). Samples were collected in June, November and December 1985 (Table 6.21). The intake locations of the three plants are shown in Figure 6.3. Analyses were undertaken for six congeners of dibenzo-p-dioxin, including 2,3,7,8-tetradibenzodioxin and for five congeners of dibenzofurans.

Results indicated that all samples of treated water at all plants were below detection for dibenzofurans. Trace quantities of tetra-, penta- and octadibenzofurans were found in raw water on one occasion only (December 2, 1985) and only at the Wallaceburg WTP. These were found at concentrations equal to the detection limit (0.00001 μg/L). All other samples were below detection.

Results for dioxin analyses are shown in Table 6.21. The Lambton WTP raw water samples (17 samples) did not have detectable dioxins. One trace value of octadibenzodioxin was recorded in treated water at Lambton (December 12). At Wallaceburg, only three in 41 (7%) raw water samples had detectable quantities of dioxin (hexa- and octadibenzodioxin, December 2 and 9). Two samples of treated water (4%) at Wallaceburg had detectable quantities of octadibenzodioxin (December 2 and 9). At Walpole, dioxins were not detectable in any of the 40 treated drinking water samples. Trace amounts of both tetra- and pentadibenzodioxin occurred in raw water on December 5. The 2,3,7,8-TCDD congener was not detected in any of the samples.

The congeners which were occasionally found (mostly octadibenzodioxin; maximum 0.00018 μg/L) are far less toxic, by up to a factor of ten thousand, than 2,3,7,8-TCDD (OMOE Drinking Water Surveillance Report for 1985/January 1986). The concentrations of dioxins in treated water were considered well below interim maximum acceptable concentration (0.000015 μg/L of 2,3,7,8-TCDD equivalent) developed jointly by Health and Welfare Canada, OMOE, Ontario Ministry of Health and Ontario Ministry of Labour. This conclusion was based on consideration of the much lower toxicity of the tetra-, penta-, hexa- and octadibenzodioxins which were found. An acceptable equivalent concentration of 0.15 μg/L for the maximum acceptable concentration would be suggested based on the 10,000-fold difference in toxicity (OMOE Drinking Water Surveillance Report 1985/January 1986). The Michigan WQS, Rule 57(2) for 2,3,7,8-TCDD is 1.4×10^{-8} μg/L, however, this value can be adjusted to assess the toxicity of other TCDD congeners. The value for the other congeners would be higher than for 2,3,7,8-TCDD. Because the

Table 6.21 Results of dioxin surveys conducted by OMOE, Health and Welfare Canada and Carleton University in raw (ambient) and treated drinking water at three water treatment plants within the St. Clair River AOC during 1985 (OMOE Drinking Water Surveillance Report, 1985/January 1986 update). Intake locations shown in Figure 6.3.

Location	Sample	Month /Day	Chlorinated Dibenzo-p-dioxins (μg/L)					
			2,3,7,8-T_4CDD	T_4CDD (tetra)	P_5CDD (penta)	H_6CDD (hexa)	H_7CDD (hepta)	O_8CDD (octa)
Lambton Area (Sarnia)	raw	06/17	ND	ND	ND	ND	ND	ND
	treated	06/17	ND	ND	ND	ND	ND	ND
	raw	11/15	ND	ND	ND	ND	ND	*
	treated	11/15	ND	ND	ND	ND	ND	*
	raw	12/09	ND	ND	ND	ND	ND	ND
	treated	12/09	ND	ND	ND	ND	ND	T≤0.000022
Wallaceburg	raw	06/24	ND	ND	ND	ND	ND	ND
	treated	06/24	ND	ND	ND	ND	ND	ND
	raw	11/15	ND	ND	ND	ND	ND	*
	treated	11/15	ND	ND	ND	ND	ND	*
	raw	11/26	ND	ND	ND	ND	ND	ND
	treated	11/26	ND	ND	ND	ND	ND	ND
	raw	12/02	ND	*	ND	T≤0.000013	ND	0.00018
	treated	12/02	ND	ND	ND	ND	ND	T≤0.00011
	raw	12/09	ND	ND	ND	ND	ND	T≤0.000027
	treated	12/09	ND	ND	ND	ND	ND	ND
	raw	12/16	ND	ND	ND	ND	ND	NR
	treated	12/16	ND	ND	ND	ND	ND	T≤0.000016
	raw	12/16	ND	ND	INT	INT	ND	ND
	treated	12/16	ND	ND	ND	ND	ND	ND

Table 6.21 (cont'd)

Location	Sample	Month /Day	Chlorinated Dibenzo-p-dioxins ($\mu g/L$)					
			2,3,7,8-T_4CDD	T_4CDD (tetra)	P_5CDD (penta)	H_6CDD (hexa)	H_7CDD (hepta)	O_8CDD (octa)
Walpole Island	raw	11/05	ND	ND	ND	ND	ND	*
	treated	11/05	ND	ND	ND	ND	ND	*
	raw	11/15	ND	ND	ND	ND	ND	*
	treated	11/15	ND	ND	ND	ND	ND	*
	raw	11/25	ND	ND	ND	ND	ND	ND
	treated	11/27	ND	ND	ND	ND	ND	ND
	raw	11/25	ND	ND	ND	ND	ND	ND
	treated	11/25	ND	ND	ND	ND	ND	ND
	raw	12/05	ND	T≤0.00001	T≤0.000014	ND	ND	ND
	treated	12/05	ND	ND	ND	ND	ND	ND
	raw	12/09	ND	ND	ND	ND	ND	T≤0.00001
	treated	12/09	ND	ND	ND	ND	ND	ND
	raw	12/17	ND	ND	ND	ND	ND	ND
	treated	12/17	ND	ND	ND	ND	ND	ND

ND = below method detection limit (detection limits are generally between 0.000002 and 0.000015 $\mu g/L$; refer to OMOE Drinking Water Report for 1985/January 1986 for specific values).
INT = sample interference, could not analyze.
NR = replicate determinations not comparable.
* = sample or blank contamination.
T = trace, at or near detection limit at a level too low to quantify.

detection limit listed in Table 6.21 for 2,3,7,8-TCDD is between 2.0 X 10^{-6} and 1.5 X 10^{-5} $\mu g/L$, exceedences of the Rule 57(2) value can not be determined.

6.3.1.16 Volatile Organic Compounds

Samples were taken in June of 1984 from Lake St. Clair and the channels of the St. Clair River delta by Kaiser and Comba (1986a) utilizing lower detection limits than those of OMOE. These showed measureable concentrations of several volatile organochlorine contaminants, notably tetrachloroethylene and carbon tetrachloride, entering Lake St. Clair from the South Channel, Bassett Channel and Chenal Ecarte.

Tetrachloroethylene concentrations of 0.473 and 0.287 $\mu g/L$ and carbon tetrachloride concentrations of 0.903 and 0.365 $\mu g/L$ were found at the mouths of Bassett Channel and Chenal Ecarte, respectively (Kaiser and Comba 1986a). Within the South Channel, tetrachloroethylene concentrations ranged from 0.079-0.182 $\mu g/L$ (6 samples). Carbon tetrachloride concentrations in the South Channel ranged from 0.095 to 0.264 $\mu g/L$ (6 samples). The highest concentrations were in the upstream direction. In contrast, tetrachloroethylene concentrations in the North Channel ranged from 0.007 to 0.028 $\mu g/L$ (3 samples) and carbon tetrachloride concentrations were 0.001 to 0.013 $\mu g/L$. The authors concluded that concentrations of volatile organics, particularly tetrachloroethylene and carbon tetrachloride, in these channels indicated a contaminant plume originating along the eastern shore of the St. Clair River with little or no cross-stream mixing. Relatively high concentrations of these parameters extended approximately 15 km (9.3 mi) into Lake St. Clair. At that range they were found to drop to near background concentrations (Kaiser and Comba 1986a).

The Michigan WQS (January 1991), Rule 57 Value for carbon tetrachloride is 20 $\mu g/L$ and for tetrachloroethylene is 16.0 $\mu g/L$. Although carbon tetrachloride values in the South Channel are elevated above those in central Lake St. Clair, they do not exceed the Michigan WQS. Tetrachloroethylene concentrations measured in the Kaiser and Comba survey also did not exceed the relevant Michigan WQS.

In 1985, Kaiser and Comba conducted another investigation in order to determine the location and distribution of volatile organic compounds in the St. Clair River bottom water (Kaiser and Comba 1986b). Single bottom water samples, 0.5 m (1.6 ft) off the bottom, were taken at 20 transects (Figure 6.11) in November 1985. At each location samples were taken 10 m, 25 m and 100 m (32.8, 82 and 328 ft) offshore for a total of 60 samples.

Four major volatile organic compounds, namely tetrachloroethylene, carbon tetrachloride, 1,1,1-trichloroethane and chloroform were identified. In addition, elevated concentrations of other volatiles including methylene chloride, bromodichloromethane and dibromomethane were found at stations downstream of the Dow 1st Street sewers. Thirty-four volatile organic compounds, in addition to the four major chemicals noted above, were found in trace quantities only. Concentrations of all four major volatile compounds are elevated in samples 12 through 19, all of which are located downstream of the Dow 1st Street Sewer complex and at the Cole Drain. The range of concentrations as reported by Kaiser and Comba (1986b) are as follows:

Sample stations 12 through 19, downstream of the Dow 1st Street Sewer complex:

tetrachloroethylene	0.004 - 0.740 $\mu g/L$
carbon tetrachloride	0.004 - 1.21 $\mu g/L$
1,1,1-trichloroethane	0.007 - 0.456 $\mu g/L$
chloroform	0.007 - 0.273 $\mu g/L$

Sample collected at the Cole Drain:

tetrachloroethylene	0.567 $\mu g/L$
carbon tetrachloride	0.095 $\mu g/L$
1,1,1-trichloroethane	0.103 $\mu g/L$
chloroform	4.482 $\mu g/L$

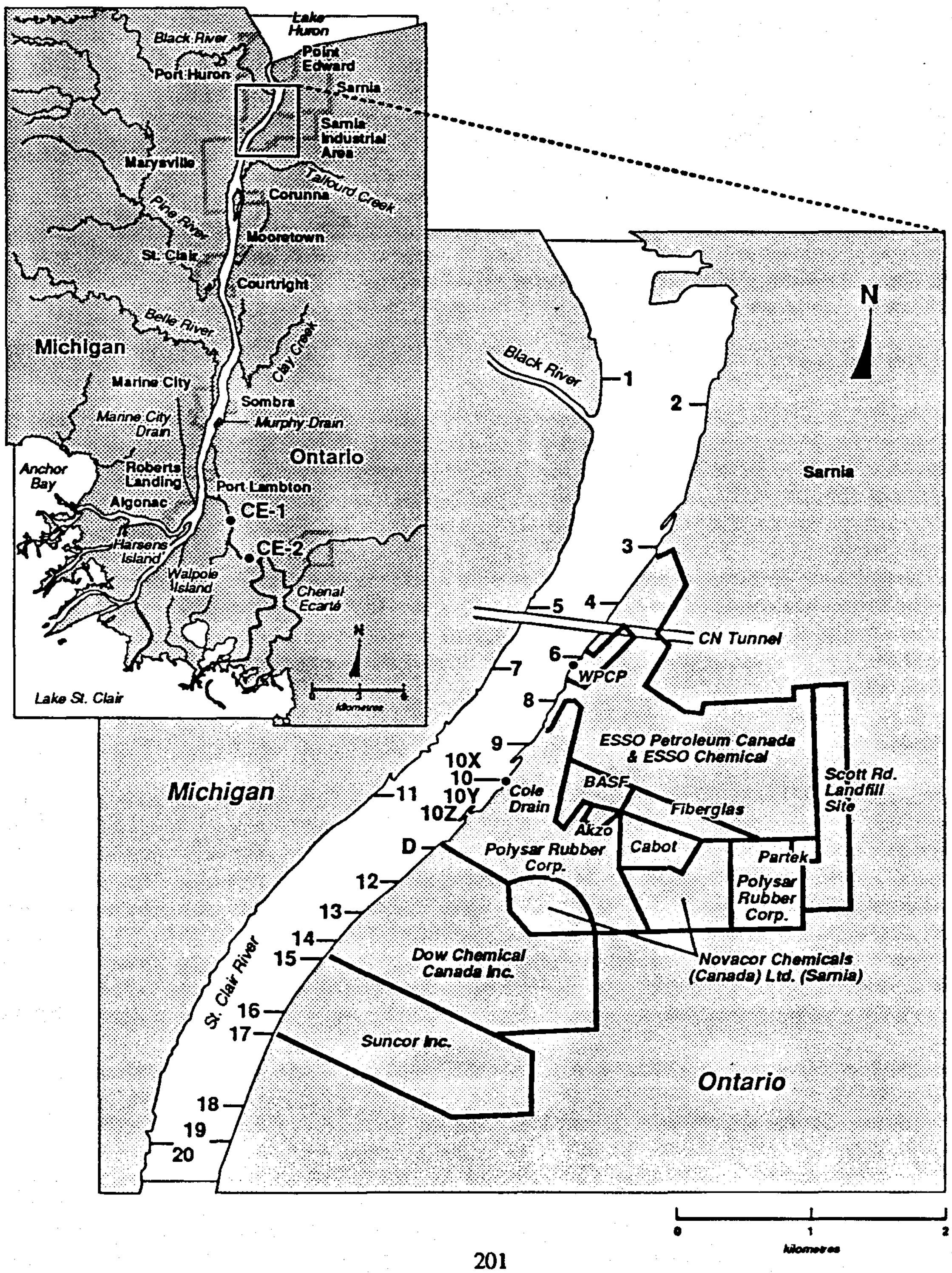
Figure 6.11

St. Clair River Remedial Action Plan

Location of the 1985 sampling locations in the upper St. Clair River for the identification and distribution of volatile organic compounds

Samples were collected 10m, 25m and 100m from shore along transects at each location

(Kaiser and Comba 1986b)



The maximum concentration of tetrachloroethylene (2.423 μg/L) was found at Station 9B located downstream of the Esso Petroleum outfall and 25 m (82 ft) offshore. The highest concentration of carbon tetrachloride (2.411 μg/L) was found at Station 4b, just upstream of the railway tunnel. One very high value of 1,1,1-trichloroethane (4.174 μg/L) was found at Station 2a, the furthest station upstream on the Canadian shoreline. The highest chloroform concentration was found at the mouth of the Cole Drain. Tetrachloroethylene, carbon tetrachloride and 1,1,1-trichloroethane all showed a sharp increase in the River at the Dow 1st St. Sewer complex. Relatively high concentrations of tetrachloroethylene (0.104 μg/L), carbon tetrachloride (0.062 μg/L), 1,1,1-trichloroethane (0.057 μg/L) and chloroform (0.036 μg/L) were found as far downstream as the Chenal Ecarte (Station CE-2).

The distribution of the four major volatile compounds revealed the presence of a slow spreading contaminant plume originating from inputs along the river, particularly in the vicinity of the Cole Drain and the Dow 1st Street Sewer complex (Kaiser and Comba 1986b). Michigan WQS (January 1991), Rule 57 Values for tetrachloroethylene (16.0 μg/L), carbon tetrachloride (20.0 μg/L), chloroform (43.0 μg/L) or 1,1,1-trichloroethane (117 μg/L) were not exceeded in any samples.

Included in the 1986 St. Clair River MISA Pilot Site Investigation were two ambient water quality surveys - centrifugation surveys to determine concentrations on suspended solids and investigative surveys on whole water (see survey description under chlorinated organics section). The results for two volatile organic compounds, carbon tetrachloride and tetrachloroethylene, from each survey are discussed below.

(1) Centrifugation

The comparison of the centrifuged solids samples to whole water analysis revealed that tetrachloroethylene and carbon tetrachloride were primarily in the dissolved form. Carbon tetrachloride was not detected in any of the 56 centrifuged solids samples. Tetrachloroethylene was detected in 42 of 56 samples (75%), however, concentrations were mostly less than 0.1 μg/g. The highest value (2.9 μg/g) occurred in the bottom sample from nearshore Station 216 which is located offshore of Suncor and downstream of Dow.

The concentration of the more soluble volatiles, such as carbon tetrachloride, tended to be higher in samples near the surface and lower at the bottom. An explanation for this behaviour could be that because the volatiles are almost entirely in aqueous solution they followed the effluent plume (OMOE 1990a). During most of the year the plume tended to rise towards the surface due to a higher effluent temperature than the ambient water.

(2) Investigative Water Sampling

Figures 6.12 and 6.13 represent the spatial distribution for tetrachloroethylene and carbon tetrachloride, respectively. These figures are based on mean values of surface and bottom samples collected at the 43 station grid shown in Figure 6.6. Mean, minimum and maximum values for each compound is provided in Table 6.20 (detection limits are higher than those of Kaiser and Comba 1986a,b). "The distribution of tetrachloroethylene [as presented in Figure 6.12], revealed an abrupt drop in concentration both laterally and in the downstream direction. Two concentration gradients emanated from the shore adjacent to the Dow 1st St. Sewer complex. One extended offshore beyond the sampling location situated 100 m (328 ft) from shore, while downstream effects were noted in only a very narrow band adjacent to shore. Concentrations at the southern Dow property line and downstream from this point were at or below the method detection limit.

The Canadian Water Quality Guideline (CCREM 1987) and the World Health Organization (WHO) human health guideline for tetrachloroethylene are 260 and 10 μg/L, respectively. The former value is recommended for the protection of aquatic life, while the WHO value is for the protection of human health based on a predetermined cancer risk of 1 X 10^{-5}. The Michigan Surface WQS (January 1991), Rule 57 value for tetrachloroethylene is 16 μg/L. Ten of the samples (3.5%) exceeded the WHO guideline and four

Figure 6.12

St. Clair River Remedial Action Plan

Tetrachloroethylene distribution in the St. Clair River during the 1986 investigative sampling survey

Based on depth averaged concentrations for all samples collected during May 26-29, July 14-17 and October 20-23 (OMOE 1990a)

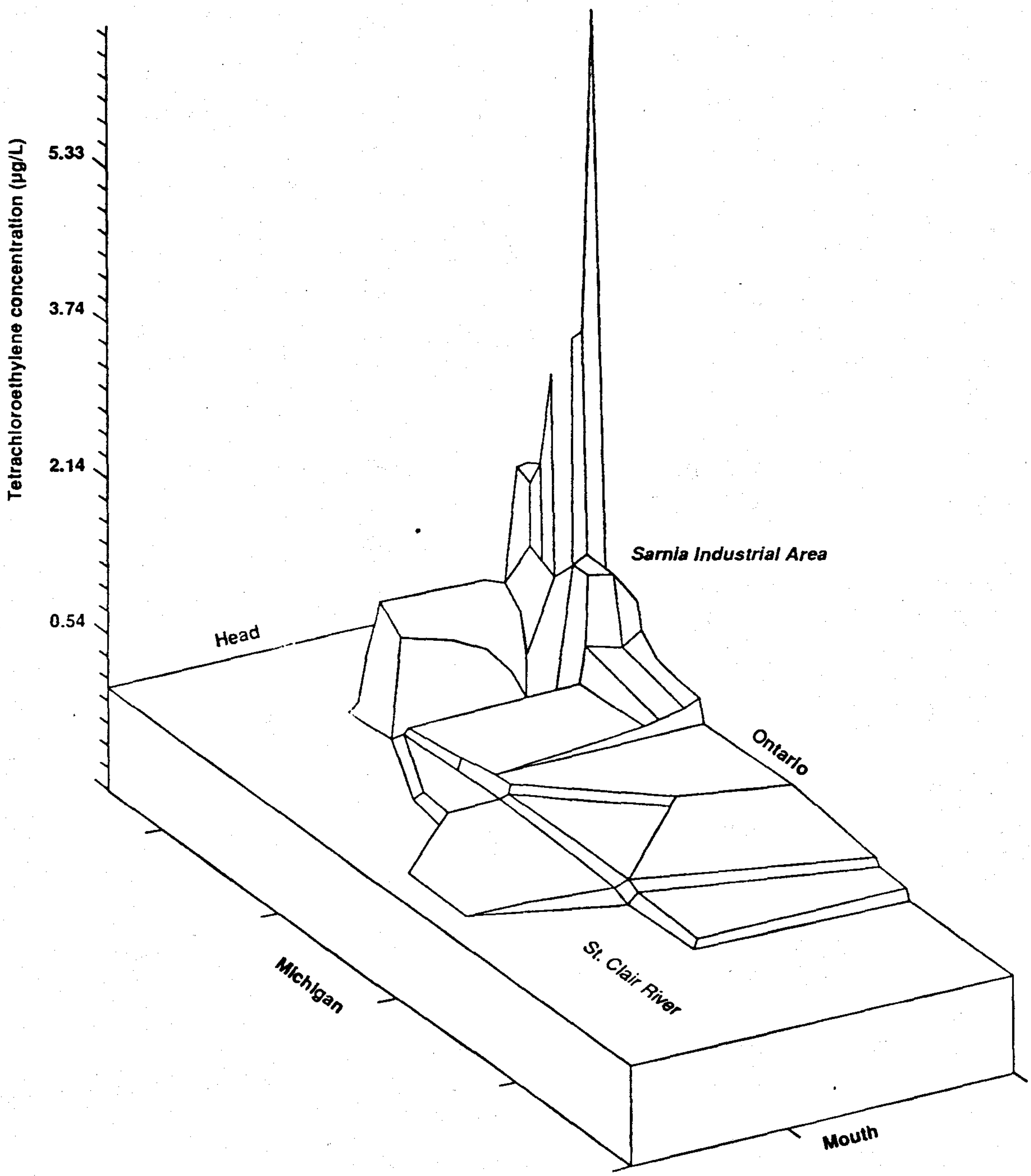
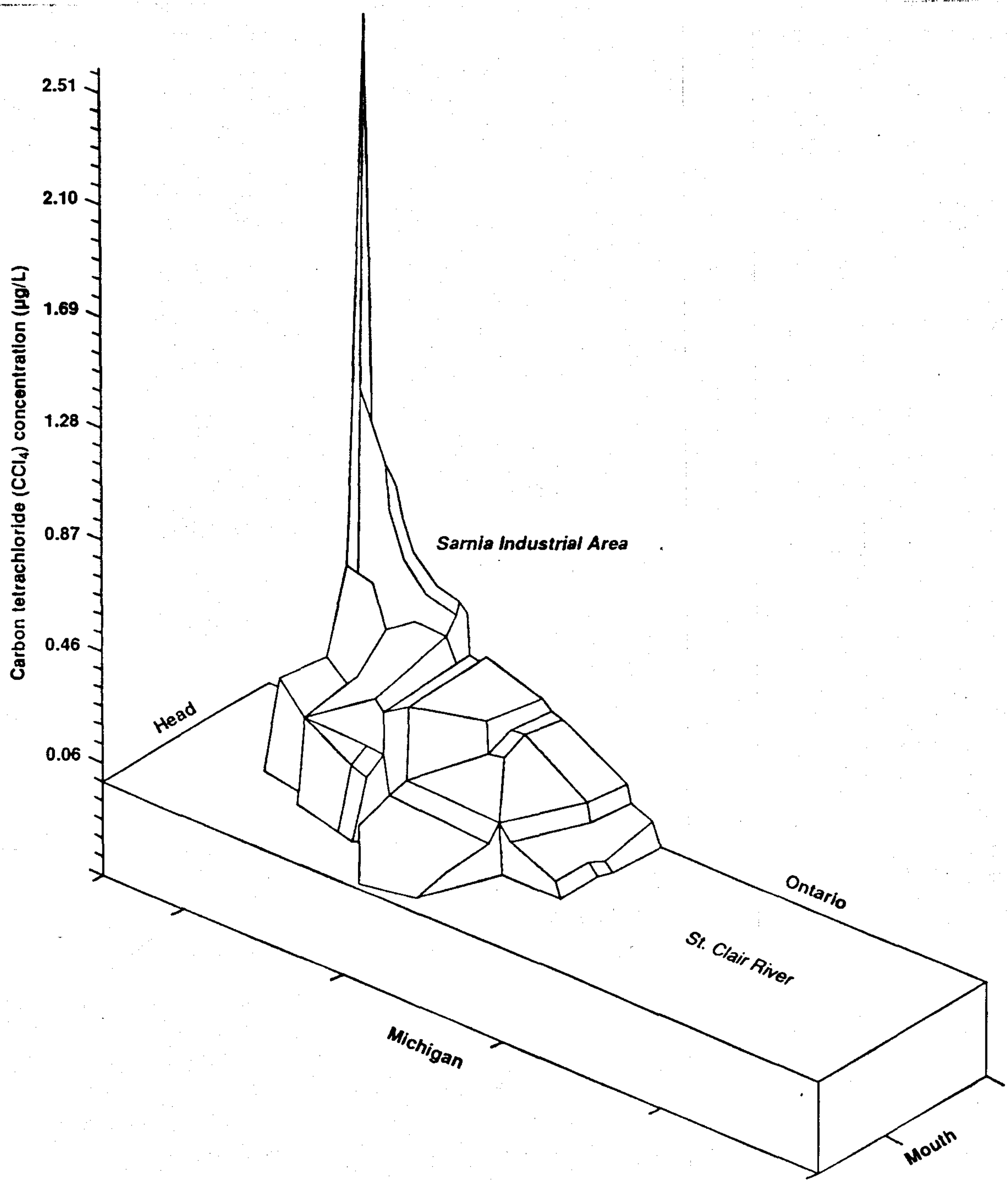


Figure 6.13

St. Clair River Remedial Action Plan

Carbon tetrachloride (CCl_4) distribution in the St. Clair River during the 1986 investigative sampling survey

Based on depth averaged concentrations for all samples collected during May 26-29, July 14-17 and October 20-23 (OMOE 1990a)



(1.4%) exceeded the Michigan WQS. The maximum concentration measured was 44.0 μg/L and 32.8 percent of samples were above the method detection level (Table 6.20). The ten samples which exceeded one or both of the guidelines were obtained adjacent to the Dow property and downstream of Suncor near the Ontario shore of the river (Stations 20, 209, 216, 217, Figure 6.6). None of the samples exceeded the CCREM guideline.

As indicated in Table 6.22, the majority of samples containing significant amounts of tetrachloroethylene were obtained during the July cruise. Coincident effluent sampling for the Dow 42-inch sewer at the 1st Street Sewer complex revealed a mean July tetrachloroethylene concentration twice the mean in the river for the 10 month period monitored, whereas during the May 26-29 period and immediately preceding the October 20-23 period the effluent concentrations were either not detectable or below the river mean. This demonstrates a cause/effect relationship between the outfall and St. Clair River ambient concentrations (OMOE 1990a).

Table 6.22 Samples measured above method detection limits (MDL) for selected parameters by cruise and depth during the 1986 investigative sampling survey (OMOE 1990a).

Parameter	MDL μg/L	May 26-29, 1986 % > MDL			July 14-17, 1986 % > MDL			October 20-23, 1986 % > MDL		
		Overall (n)	Surface	Bottom	Overall (n)	Surface	Bottom	Overall (n)	Surface	Bottom
Hexachlorobenzene	0.001	27.1(85)	16.3	38.1	48.9(94)	36.2	61.7	51.1(92)	37.8	63.8
Hexachlorobutadiene	0.001	47.1(85)	34.9	59.5	46.8(94)	42.6	51.1	42.4(92)	35.5	48.9
Hexachloroethane	0.001	50.6(85)	39.4	61.9	2.1(94)	2.1	2.1	29.3(92)	31.1	27.7
Octachlorostyrene	0.001	0(85)	0	0	19.1(94)	10.6	27.7	3.3(92)	4.4	2.1
2,4,5-Trichlorotoluene	0.001	4.7(85)	6.98	4.8	0 (94)	0	0	5.4(92)	4.4	6.4
Carbon Tetrachloride	1.0	6.4(94)	8.5	4.3	43.2(95)	46.8	39.6	26.9(93)	33.3	20.8
Tetrachloroethylene	1.0	35.1(94)	34.0	36.2	44.2(95)	46.8	47.9	17.9(95)	19.2	16.7

The Michigan WQS (January 1991), Rule 57 Value for carbon tetrachloride (20 μg/L) was exceeded by one sample which had a concentration of 42 μg/L (Table 6.20). This sample was taken from Station 20 (Figure 6.6) offshore of Dow. In addition, elevated values occurred downstream of the Dow 1st Street Sewer complex. The maximum value of 0.042 μg/L was found at station 20 (Figure 6.10). The spatial distribution of carbon tetrachloride (Figure 6.13) is more wide ranging than that of tetrachloroethylene (Figure 6.12), perhaps due in part to its higher solubility (OMOE 1990a).

> "Parameters such as carbon tetrachloride and tetrachloroethylene with solubilities of 800 and 150 μg/L respectively should disperse relatively rapidly throughout the water column. This was generally observed and was particularly evident during the July cruise when ambient and effluent temperatures were similar. During May and October, the effluent temperature exceeded the receiving water, resulting in a buoyant plume and consequently, more contaminants associated with the surface samples (Table 6.22). This was more evident at nearfield locations and became less significant as mixing occurred further downstream" (OMOE 1990a).

6.3.1.17 Water Treatment/Filtration Intake Closures

Water Treatment/Filtration Plant intakes in both Michigan and Ontario have been closed periodically due to spills at upstream industrial facilities. The water treatment plants are shutdown mostly as a precautionary measure. In some instances, this precaution is based on predictions from models regarding the possible concentration of the contaminant as it passes the intake. Often the threat of contamination is minimal, particularly on the Michigan side, however, closure of the intakes ensures maximum protection. Although the models predict some cross channel migration of spilled material, particularly in the lower river, concentrations on the U.S. side are typically less than 5 percent of levels measured along the Ontario shoreline (P. Nettleton, OMOE, pers. com.).

In December, 1989 MDNR requested information from seven water filtration plants having intakes in the St. Clair River regarding drinking water intake shutdowns related to spills. Responses were received from Marysville and East China Township. Reports of shutdowns at other water treatment plants, including Algonac, Marine City and Old Club, have also been received (T. Benton MDPH. pers. com.). Documented water intake closures have occurred at Walpole Island and Wallaceburg in Ontario as well as at Marysville and East China, Michigan.

The Wallaceburg Water Treatment Plant intake was closed following an incident in March 1989. A spill of Selexol (polyethylene diethyl ether) from ICI resulted in concentrations of Selexol in the raw water which would have entered the intake at 24 to 243 $\mu g/L$ (John Luyt, OMOE, Sarnia, per. comm.). A temporary guidance value for Selexol of 60 $\mu g/L$ was developed by Health and Welfare Canada subsequent to the spill. On October 30, 1990, approx 3,600 kg of ethylbenzene from Dow Chemical resulted in the closure of water treatment plant intakes at Walpole Island and Wallaceburg. Maximum concentrations at the Walpole intake were 40.2 $\mu g/L$ and at Wallaceburg were 44.4 $\mu g/L$ (Wayne Wager, OMOE, Sarnia, pers. com.). The Canadian Drinking Water Quality Guideline for taste and odour is 2.4 $\mu g/L$ of ethylbenzene. As a precautionary measure, the WTP intakes were closed and food processors in Wallaceburg shutdown. Water within the distribution system of Wallaceburg had concentrations of ethylbenzene > 5 $\mu g/L$ and, hence, the food processors remained closed until the system was flushed. As recently as May 8, 1991 another spill of ethylbenzene from Dow resulted in the closure of the Walpole Island Water Treatment Plant.

The East China Water Filtration Plant experienced a total of 12 shutdowns between January 1978 and February 1990 due to upstream spills. The costs incurred by the facility as a result of these shutdowns was $2,511.00 (Richard Golder, Superintendent of Water and Wastewater, Township of East China, letter to Mr. R. Day, MDNR, March 9 1990). Some of the closures experienced by this facility were due to spills or losses from the Detroit Edison thermal electric station (T. Benton, MDPH, pers. com.). From August 13, 1985 to February 23, 1990, the Water Filtration Plant for the City of Marysville experienced 31 shutdowns due to spills. Total costs associated with these events was $300.00 (R. Ashley Grant, Assistant Director, Public Utilities, City of Marysville, letter to Mr. R. Day, MDNR, April 18, 1990). Intake closures at this facility were noted as being due to spills from various Ontario and Michigan sources including Polysar, Suncor, Esso Petroleum, Esso Chemical, Dow Chemical and the Port Huron WWTP. Closures of the Marysville WFP as a result of spills from Ontario sources were not due to specific advice from OMOE, but were strictly as a precautionary measure based on notification of the spill event.

Carbon filtration has been added to the Wallaceburg and Walpole Islands WTP for added treatment of organic contaminants associated with spills. In addition, water filtration plants in Michigan have been advised to provide for activated carbon treatment (T. Benton, MDPH, pers. com.).

6.3.1.18 Drinking Water Taste and Odour

There are no records of taste and odour complaints on file with the Sarnia office of OMOE nor with either the Lambton or Wallaceburg Water Treatment Plants. However, the Wallaceburg Water Commission has developed a Contamination Response Plan whereby spill events are acted upon. Under this program, a level II response involves notification of a spill event to the emergency coordinator along with the shutdown of the filtration plant. This response level includes, *inter alia*, impairments associated with taste and odour (L. Deays, Wallaceburg Water Commission, pers. com.). There were three occurrences of a level II response during each of 1989 and 1990. The Lambton Water Treatment Plant has not recorded any problems related to taste and odour (J. Horsburgh, OMOE, pers. com.).

6.3.1.19 Aesthetics

Aesthetic water quality concerns relate to the presence of substances in the water which degrade the visual quality of the water and/or contribute obnoxious odours. Although not specifically documented, concerns relating to aesthetic degradation in the river due to floating 'debris', scum and oil sheens have been noted by members of the Binational Public Advisory Council for the St. Clair River RAP. In addition, many of the spills reported to the Spills Action Centre of OMOE result in the degradation of aesthetics, particularly those associated with oils and gasoline. Spill occurrences and magnitudes are documented in Chapter 8. Locations where aesthetic degradation has been reported by citizens and newspaper articles include Sarnia Bay, Clay Creek (sedimentation), near the St. Clair River mouth, near combined sewer overflow outfalls and most tributaries to the river. Spill occurrences relate mostly to ship traffic, docking facilities and industries.

6.3.1.20 Water Quality Summary

Results of water surveys in the St. Clair River reveal a pattern of contamination by industrial organics primarily from Ontario sources. The most contaminated portion of the river, as identified by concentrations which are elevated above those at the head of the river or laterally across the river, by conductivity, and water quality guideline exceedences, is governed by the flow pattern of the river. The majority of the contaminants in the St. Clair River waters originate in the industrial area south of Sarnia. A contaminant plume tends to hug the Canadian shoreline from the Cole Drain, south of Sarnia, and gradually enlarges downstream where it extends up to 300 m (984 ft) from the Canadian shore at Port Lambton. The flow pattern of the river funnels the plume into the Chenal Ecarte and South Channel at the delta.

Exceedences of Objectives, Guidelines and Standards

Water quality objectives, guidelines and standards which were exceeded in the St. Clair River are presented in Table 6.23 along with the location, date and degree of exceedence. Contaminants which exceed, Canadian Guidelines, Great Lakes Water Quality Agreement Objectives and/or Provincial Water Quality Objectives include, fecal coliform bacteria, cadmium, copper, iron, zinc, hexachlorobutadiene, hexachlorobenzene and octachlorostyrene. The discharge of inadequately treated sewage from Michigan CSOs during runoff events also causes impairments downstream of the outfalls. Michigan Water Quality Standards (January 1991) were exceeded for chloride, cadmium, copper, lead, mercury, zinc, hexachlorobenzene, dieldrin, total PCBs, hexachlorobenzene, tetrachloroethylene and carbon tetrachloride.

Copper exceeded the PWQO and GLWQA Objective by up to 4 times (average) and the Michigan WQS, Rule 57 Value by up to 2 times at the Lambton (Sarnia area) and Walpole Island water intakes in 1988. The source of the copper to the Lambton WTP, which draws its water from Lake Huron, is unknown but is clearly upstream of the AOC. Iron exceeded the PWQ and GLWQA Objectives, however, the pattern of contamination does not indicate likely sources within the AOC.

The Provincial Water Quality Guideline for phosphorus was occasionally exceeded prior to 1986, however, the ambient concentrations in 1986 and 1988 were generally well below the guideline. Ammonia exceeded the PWQO within the industrial area in 1977, however, recent data collected at the water treatment plant intakes suggest that this parameter is below objectives for the protection of aquatic life. Chloride concentrations are elevated in the contaminant plume on the Ontario side with 1986 concentrations

Table 6.23 Summary of ambient water quality criteria exceedences for the St. Clair River Area of Concern.

Parameter/Factor	Guideline or Objective (µg/L)	Year and Location of Exceedence (µg/L)
Chloride	MWQS[1] 50,000	1986 -adjacent to Sarnia industrial waterfront (105,000; max)
Phosphorus	PWQO[2] 30	1977 -Ontario shoreline (77/12; max/mean) 1985 -Wallaceburg water intake (45/50; max/mean) 1988 -Wallaceburg water intake (45; one only)
Bacteria	PWQO 100 org./100 mL MDNR 200 org./100 mL	1990 -5 Ontario beaches closed for varying periods (102.4 to >600 org/100mL; geometric means)
Mercury	PWQO & GLWQA[3] 0.2 MWQS 0.0013	1974 -head of river (4.6; mean) -just north of Chenal Ecarté (2.4; mean) 1984 -downstream of Sarnia industrial outfalls (0.011; mean) and Chenal Ecarté (0.1; mean) 1986 -offshore and downstream of industrial area (0.02 to 0.03; range) 1988 -Lambton, Walpole Island and Wallaceburg WTPs (0.03, 0.02 & 0.01, respectively; means)
Iron	PWQO & GLWQA 300	1976 -below Sarnia to Port Lambton (20 to 440) 1985 -Chenal Ecarté (600; mean)
Lead	MWQS 2.88	1986 -downstream of the mouth of the Black River (10; max) 1988 -Walpole Island water intake (3.9; max)
Zinc	PWQO & GLWQA 30 MWQS 49.57	1988 -Walpole Island water intake (66; max)
Copper	PWQO & GLWQA 5 MWQS 10.72	1988 -Lambton water intake (19.75/52; mean/max) -Walpole Is water intake (7.98/73;mean/max)
Cadmium	PWQO & GLWQA 0.2 MWQS 0.41	1986 -Dow and Suncor outfalls (2; max)
Hexachlorobutadiene	CCREM[4] 0.1	1985 -2 stations downstream of Cole Drain (0.114 and 0.150) 1986 -downstream of Cole Drain (0.053 to 0.116) -downstream of Dow 1st St. complex (0.116; max)
Hexachlorobenzene	PWQO 0.0065 MWQS 0.0018	1984 -100 to 600 m (328 to 1968 ft) downstream of Dow 1st St. complex (0.4/2.4; avg/max) 1985 -Cole Drain to head of Stag Is (0.131; max) 1985 -Cole Drain to downstream of Bowens Creek with maximum values near Dow, Polysar and Esso (0.002 to 0.087; range of 8 exceedences) 1985 -mouths of Talfourd Creek (0.034) and Bowens Creek (0.0028) 1986 -below Cole Drain (0.23; max) -below Dow 1st St. sewer (0.21; max)

Table 6.23 (cont'd)

Parameter/Factor	Guideline or Objective (μg/L)		Year and Location of Exceedence (μg/L)
Octachlorostyrene	OMOE[5]	0.0001	1985 -Sarnia WPCP to downstream of Bowens Creek with maximum concentrations near Dow, Polysar and Esso (0.00013 to 0.0072; range of 8 exceedences) 1985 -Port Lambton, Chenal Ecarté, South Channel (0.007-0.085; max. at Port Lambton) 1985 -mouths of Talfourd Creek (0.0016) and Bowens Creek (0.00036) 1986 -downstream of the Cole Drain and past the Dow and Suncor outfalls (0.02; max)
Tetrachloroethylene	MWQS	16.0	1986 -adjacent to Dow Chemical (44; max; 10 samples > 10.0μg/L)
Total PCBs	MWQS CCREM	0.00002 0.001	1985 -both criteria exceeded at all eleven stations including head of river, both sides, at 6 locations across river at Port Lambton and 3 locations in the delta (0.0012; mean and ND - 0.0035; range)
Dieldrin	MWQS CCREM	0.0000315 0.001	1985 -throughout St. Clair River (0.00016 to 0.000425; range) 1986 -(0.002/0.00001; max/mean)
Carbon Tetrachloride	MWQS	20	1986 -offshore of Dow (42; max)
Spills	Water Treatment Plant Shutdowns		Jan. 1978 to Feb. 1990-Township of East China, Michigan (12 shutdowns) Aug. 1985 to Feb. 1990-City of Marysville, (31 shutdowns) 1989 -Selexol, Wallaceburg WTP 1990 -Ethylbenzene, Wallaceburg WTP

[1] Michigan Water Quality Standard, Rule 57 Value (January 1991 version).
[2] Provincial Water Quality Objective (PWQO) for the Protection of Aquatic Life (OMOE 1984).
[3] Great Lakes Water Quality Objective (Chapter 4)
[4] Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CCREM 1987).
[5] Ontario Ministry of the Environment, Water Quality Advisory (OMOE 1990a).

increasing by more than an order of magnitude from upstream of the Sarnia industrial complex to immediately offshore of the industrial area. There is no PWQO for chloride, however, increasing concentrations both downstream and from 1985 to 1988 are of concern. Also, the maximum chloride concentration adjacent to the Ontario industrial waterfront exceeded the Michigan Surface WQS during 1986.

The focus of water quality surveys in the 1980s has been on organic industrial contaminants. The highest concentrations of hexachlorobutadiene, hexachlorobenzene, octachlorostyrene, hexachloroethane, carbon tetrachloride, pentachlorobenzene, chloroform, tetrachloroethylene and 1,1,1-trichloroethane in water occur immediately downstream of the Cole Drain and/or the Dow 1st Street Sewer complex. Hexachlorobenzene in this area exceeded the PWQO (0.0065 μg/L) and the Michigan Surface WQS (January 1991), Rule 57 Value (0.0018 μg/L). Hexachlorobenzene concentrations in water exceeding these guidelines, measured from 1984 through 1986, originate downstream of the Cole Drain and remain as exceedences up to the head of Stag Island near Corunna (OMOE 1990a).

Octachlorostyrene concentrations were found to exceed the OMOE interim guideline (0.0001 μg/L) from downstream of the Cole Drain, Dow and Suncor outfalls, and down-river within 100 m (328 ft) of the Canadian shoreline at Port Lambton and in the delta channels, Chenal Ecarte and South Channel. Hexachlorobutadiene concentrations exceeded the Canadian Water Quality Guideline (0.1 μg/L) for the protection of aquatic life downstream of the Cole Drain and Dow 1st Street Sewer complex.

Total PCB concentrations in whole water during 1985 exceeded the Michigan Surface WQS (January 1991), Rule 57 Value (0.00002 μg/L) at 11 stations located throughout the river. These included stations located at both the head and mouth of the river and no pattern relating to sources within the AOC could be identified.

Parameters Elevated Above Background Concentrations

Other parameters found in the plume along the Ontario shore at concentrations which were elevated above those upstream of the plume (head of river or Lake Huron), but either did not exceed guidelines or for which no guidelines are available, include hexachloroethane, pentachlorobenzene, 1,1,1-trichloroethane and chloroform. Minor organics exhibiting elevated levels in the Sarnia area are methylene chloride, bromodichloromethane and dibromomethane.

Concentrations of tetrachloroethylene and carbon tetrachloride were found in the St. Clair delta channels, particularly in South Channel, and at the mouths of South Channel, Bassett Channel and Chenal Ecarte in concentrations which were elevated relative to those in central Lake St. Clair. Higher concentrations of both parameters in the South Channel relative to the North Channel or in Lake St. Clair suggest a contaminant plume which originates along the Ontario side of the St. Clair River.

Hexachlorobutadiene, hexachlorobenzene and octachlorostyrene in Talfourd and Bowens Creeks and the Pine River (Michigan) occurred at concentrations elevated above those typically found at the head of the St. Clair River, suggesting that these tributaries may also serve a sources of contaminants.

Historical Trends

Levels of mercury in the Clair river waters have been reduced by up to two orders of magnitude between 1973 and 1988:

- in 1973, mercury concentrations in water were 4.6 and 2.4 μg/L at the head and mouth of the river respectively;
- in 1984, whole water samples had mercury concentrations at or below detection (0.01 μg/L) for most of the river with locally elevated maximum concentrations

averaging 0.1 $\mu g/L$ offshore of the Sarnia industrial area and Chenal Ecarte respectively;

- in 1986, whole water samples were also generally at or below detection (0.01 $\mu g/L$) throughout the river and maximum concentrations were reduced to 0.03 $\mu g/L$, found downstream of Dow and Suncor; and

- in 1988, whole water samples with annual means of 0.03, 0.02 and 0.01 at the intakes for the Lambton, Walpole Island and Wallaceburg Water Treatment Plants.

The maximum concentrations recorded in 1984 and 1986, as well as the pattern of suspended solids concentrations in the 1984 samples, indicate that, although the concentration of mercury is generally declining within the AOC, mercury continues (as of 1986) to be discharged in industrial effluents from the Sarnia area. In addition, even the most recent (1988) concentrations of total mercury were higher than the Michigan Rule 57(2) value (January 1991) for methylmercury (0.0013 $\mu g/L$).

The average and maximum concentrations of hexachlorobenzene downstream of Dow's 1st St Sewer complex were lower in 1985 and 1986 than 1984. However, due to a lack of historical data for industrial chlorinated organics, and the high variability in effluent discharges from industrial sources, it is not possible to identify trends in organic contaminant concentrations in whole water or suspended solids for the St. Clair River. Additional historical information on volatile organics is expected to be available for the Stage 2 update.

6.3.2 Sediment Quality

Bottom sediments along the Ontario shoreline of the St. Clair River have been severely contaminated with a variety of inorganic and organic chemicals from industrial activity (U.S. EPA 1975 and 1977, U.S. Corp of Engineers 1983, Oliver 1988). Elevated levels of heavy metals such as mercury, lead, copper, zinc and iron were found below Ontario industrial point sources along the river in surveys conducted by OMOE in 1977 (Oliver 1988). Organic components such as PCBs, octachlorostyrene and oil and grease have also been found at elevated levels below Sarnia's industrial district (OMOE 1977 and Pugsley et al. 1985). Severe impairment of the benthic community in 1968 along the entire length of the Ontario side of the river downstream of the industrial complex was attributed to contaminated bottom sediments (Thornley 1985). This zone decreased to about 20 km (12.4 mi) in 1977 and 12 km (7.4 mi) in 1985 (see Section 6.3.3).

The environmental impact of this contamination is not confined to the St. Clair River. High concentrations of mercury found in bottom sediments of Lake St. Clair and in the western basin of Lake Erie were attributed to sources on the St. Clair River (Oliver 1988). Similarly, sources in the St. Clair River AOC have contributed to elevated sediment concentrations of hexachlorobenzene (Oliver and Bourbonniere 1985), octachlorostyrene (Pugsley et al. 1985), and PCBs (Frank et al. 1977) in Lake St. Clair.

6.3.2.1 Mercury

The most recent data on heavy metal contamination of bottom sediments of the St. Clair River are Environment Canada/OMOE (1986), OMOE (1987), Mudroch and Hill (1989) and the MISA Pilot Site Investigation (OMOE 1990a).

From 1972 through 1976 the maximum concentrations of mercury in river bottom sediments of the St. Clair River were found 30 m (100 ft) offshore in the river reach immediately below Dow Chemical. Mean concentrations in this reach ranged from 26.8 to 89.6 $\mu g/g$ with no evident trend over the period of record (OMOE 1977). The maximum values were 112 $\mu g/g$ (1973) and 150 $\mu g/g$ (1976). These concentrations exceeded the Ontario guideline for dredged material disposal in open waters for mercury (0.3 $\mu g/g$) and the U.S. EPA interim guidelines for disposal of Great Lakes harbor sediments (heavily polluted - 1.0 $\mu g/g$). Stations located in Lake St. Clair were found to have decreasing mercury sediment concentrations between

1970 and 1976 (OMOE 1977). This has been attributed to a decrease in loadings to the St. Clair River following control and eventual closing of the Dow mercury cell chloralkali plant (Environment Canada /OMOE 1986).

Six sediment cores were collected along the Sarnia industrial waterfront from Esso Petroleum to downstream of Suncor in November 1985 (Environment Canada/OMOE 1986). Mercury concentrations in surface layers were lowest (0.18 μg/g) in the core collected offshore of Esso Petroleum, upstream of Polysar. The highest concentration in the upper 3 cm (1.2 in) was found offshore of Dow (28.0 μg/g). Surface concentrations decreased downstream to 3.3 μg/g offshore of the Dow/Suncor property boundary and remained at about that concentration to the sample collected approximately 2 km (1.2 mi) downstream of Suncor. The surface and subsurface layers of 5 of the 6 cores all exceeded both the Ontario and EPA disposal guidelines.

The core collected offshore of the Dow/Suncor property boundary had significantly lower concentrations of mercury (<4.3 μg/g) in the upper 13 cm (5 in) than in the 18 to 24 cm (7 to 9.4 in) depth (35 μg/g). This deeper section was radionuclide dated to be about 30 years old and mercury contamination at this depth was attributed to higher past discharges of mercury (Environment Canada/OMOE 1986).

This pattern of higher mercury concentration with core depth was also reported for samples collected in June 1986 by Mudroch and Hill (1989). Cores were collected off Esso Petroleum, Dow Chemical, Suncor and Port Huron Michigan. They noted that the concentration profiles suggested inputs of mercury to the river over the previous 10 years in the reach from Dow to immediately below Suncor and, further, that contaminated sediments were transported downstream from the source. The surface layers of each core, exceeded the Ontario and U.S. EPA disposal guidelines.

Oliver (1988) summarized the results of the Ontario Ministry of the Environment's complete river survey undertaken in 1985 (OMOE 1987). A total of 49 surficial sediment grab samples were collected along the entire length of the Ontario shore, 23 near the Michigan shore and in the U.S. channels of the delta, and 5 near mid-river. The sample locations and complete data set for nutrients, metals and organic contaminants are provided in Appendix 6.2. The mean concentration and range of mercury, as calculated by Oliver (1988) are shown in Figures 6.14A and 6.14B. Data were summarized to represent nine reaches of the St. Clair river along the Ontario side from head to mouth.

The data for mercury are comparable to the results for the upper 3 cm (1.2 in) of the cores collected during the November 1985 survey reported by Environment Canada/OMOE (1986). Lowest sediment concentrations were found in the uppermost reach of the river where the mean and upper range were below the Ontario and U.S. EPA disposal guidelines of 0.3 μg/g and 1.0 μg/g, respectively (Figure 6.14A). Mean and maximum concentrations in the other 8 reaches as well as minimum concentrations in 6 of the 8 reaches all exceeded the Ontario disposal guideline for mercury. The U.S. EPA guideline was exceeded by maximum and means in the five reaches downstream of Esso Petroleum. The highest value (51 μg/g) was recorded adjacent to Dow but high levels were also seen at all sites below the Cole Drain (Appendix 6.2). These values are lower than peak values observed in the late 1960s and 1970s but as of 1985 continued to exceed the disposal guidelines and, according to Oliver (1988), demonstrated a continuing local source of mercury.

The 1986 bottom sediment sampling program described as part of the MISA Pilot Site Investigation consisted of 23 stations located between Esso Petroleum and the Lambton Generating Station. Grab samples were collected at 10 m (32.8 ft) offshore and varying distances up to 650 m (2,132 ft) along 7 transects. The sample locations and complete data set, including metals, nutrients and organic contaminants are provided in Appendix 6.3. Concentrations of mercury were extremely high in the sediments at stations located 400 m (1,312 ft) downstream of Dow's 1st Street Sewer complex and at the 2nd Street Sewer (both 52 μg/g) (Figure 6.15). Maximum and average concentrations at the upstream station were 7.6 and 2.6 μg/g, respectively, both of which exceeded the disposal guidelines. The OMOE disposal guideline for mercury was exceeded in 26 of 46 samples (56.5%) and the U.S. EPA heavily polluted guideline was exceeded in 20 of 46 samples (43.5%). The concentrations were considered by OMOE (1990a) to represent ongoing inputs as of the sample collection date (1986).

6.3.2.2 Other Metals

Sediment cobalt and cadmium levels were consistently low and reasonably constant over the entire length of the river in the 1985 OMOE complete river survey (Figures 6.14A and B, Appendix 6.2). Dredge material disposal guidelines were not exceeded for either cadmium (OMOE, 1.0 µg/g; U.S. EPA heavily polluted, 6 µg/g) or cobalt (OMOE, 50 µg/g) by mean concentrations. However, maximum cadmium values slightly exceeded the Ontario guideline in four of the reaches.

Mean copper concentrations exceeded the disposal guideline (Ontario and U.S. EPA moderately polluted, 25 µg/g) in the 2 reaches immediately downstream of Esso Petroleum (Figure 6.14A). Maximum concentrations in the two reaches downstream of Esso Petroleum also exceeded the U.S. EPA heavily polluted guideline (50 µg/g). The pattern suggest inputs from Sarnia area sources with the maximum concentration of copper (190 µg/g) occurring just downstream of Sarnia's Water Pollution Control Plant.

Mean iron concentrations exceeded the Ontario disposal guideline (10,000 µg/g) in 5 of the 9 reaches. Upper range concentrations exceeded this guideline in seven reaches. The U.S. EPA moderately polluted category (17,000 to 25,000 µg/g) was reached by maximum values in the headwater reach and three downstream reaches. The maximum concentration of iron occurred offshore of Corunna, just south of Beckwith Street (Oliver 1988). Sources for iron are not readily identifiable on the basis of the sediment contamination pattern. Exceedences of guidelines occur both upstream and downstream of the industrial and municipal inputs and there is no consistent downstream trend.

In 1983, lead in bottom sediments downstream of Ethyl Corporation had a concentration of 640 µg/g (Chau et al. 1985). This concentration greatly exceeded the Ontario and U.S. EPA (heavily polluted) guidelines for dredged material disposal in open waters for lead (50 µg/g and 60 µg/g, respectively). During the 1985 OMOE complete river survey, all lead concentrations were low and below the dredge disposal guidelines for all reaches except for the maximum value in the reach below Suncor which includes Ethyl Corporation (Figure 14A). The three stations (stations 32, 34 and 36, Appendix 6.2) immediately downstream of Ethyl Corp recorded the highest concentrations along the Ontario shore with values ranging between 160 and 330 µg/g (Appendix 6.2). The highest concentration occurred closest to Ethyl with downstream concentrations decreasing systematically. One additional exceedence occurred in the reach below Sombra where the upper range value was reported as 66 µg/g (Station 61).

The 1986 MISA Pilot Site Investigation included bottom sediment sampling along the shore and along cross-river transects along the industrial waterfront (OMOE 1990a). Figures 6.15 to 6.18 show the sediment concentrations of mercury, cobalt, zinc, cadmium, copper, nickel, chromium and lead. The sediment concentrations of chromium, copper, nickel and lead were greatest in the sediments collected at Dow's 1st Street Sewer complex and decreased with increasing distance from the Canadian shore. The highest concentrations of cadmium and zinc occurred in the sediments downstream of the Dow 4th Street Sewer, nearest the Canadian shore.

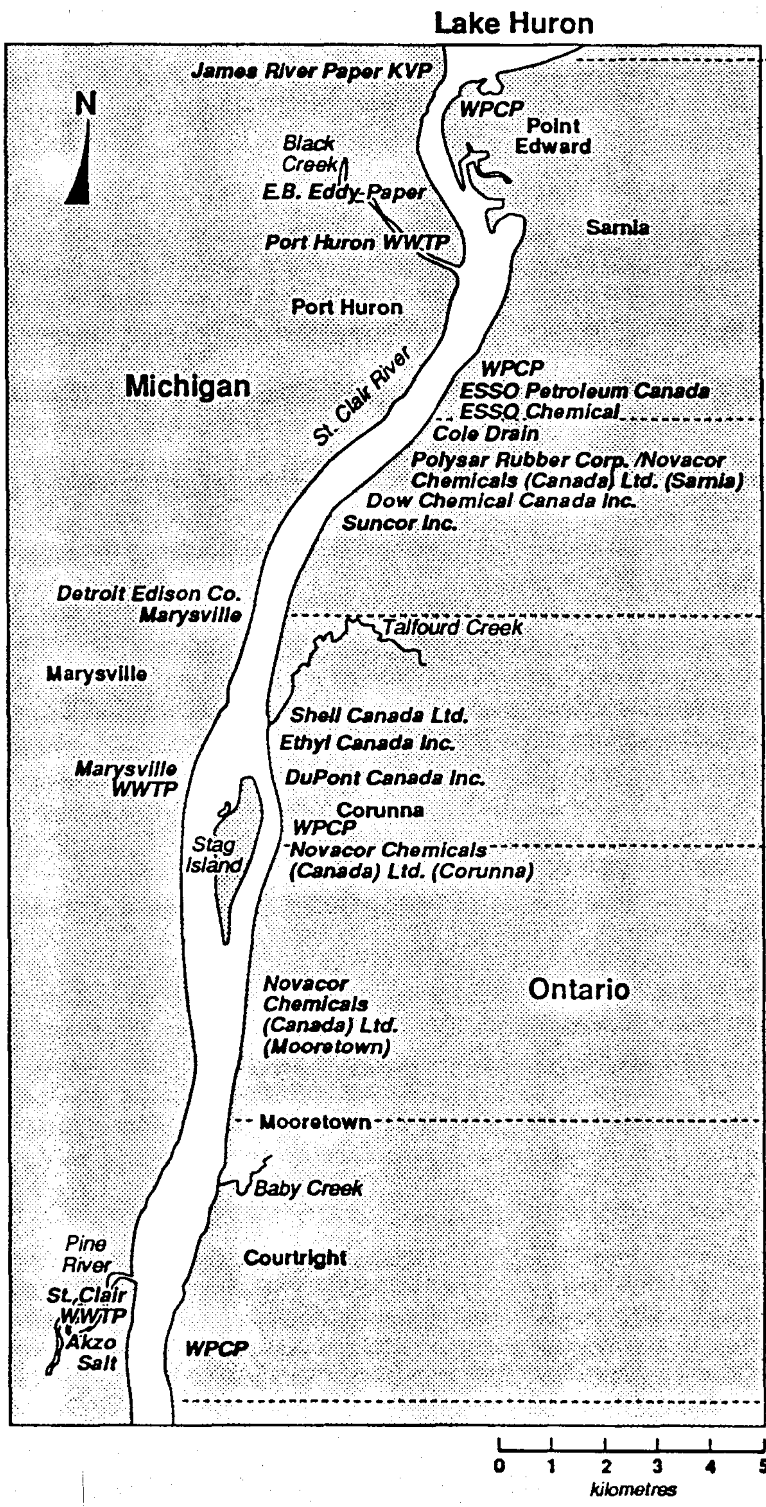
The Ontario dredged material disposal guidelines for copper (25 µg/g), zinc (100 µg/g) and chromium (25 µg/g) were exceeded in sediments collected within 100 m (328 ft) of the Dow Chemical waterfront, downstream of the 1st Street Sewer Complex (Figures 6.16, 6.17 and 6.18; Appendix 6.3). Maximum and mean concentrations for this station were 35 and 17.9 µg/g copper; 690 and 137 µg/g zinc; and 37 and 21 µg/g chromium (OMOE 1990a). Of 40 samples, 7 (17.5%) equalled or exceeded the guideline for chromium; 23 (57.5%) equalled or exceeded the guideline for copper; and 17 (42.5%) exceeded the guideline for zinc. The lower range of the U.S. EPA moderately polluted category is the same as Ontario's guidelines for copper and chromium; for zinc the U.S. EPA moderately polluted category is 90 to 200 µg/g.

Figure 6.14A

St. Clair River Remedial Action Plan

Means and ranges (µg/g) of metals in surficial sediments for the five upper reaches of the St. Clair River during 1985

(Oliver 1988)



	Range	Mean
Hg	(ND - 0.25)	0.06
Pb	(ND - 39)	15
Cd	(ND - 0.94)	0.35
Cu	(4.9 - 35)	21
Fe	(3,700 - 22,000)	10,000
Co	(2.0 - 7.1)	4.7

	Range	Mean
Hg	(0.04 - 51)	9.2
Pb	(6.0 - 34)	20
Cd	(ND - 1.4)	0.52
Cu	(13 - 190)	65
Fe	(6,700 - 15,000)	9,500
Co	(4.0 - 14)	6.1

	Range	Mean
Hg	(0.75 - 28)	7.1
Pb	(7.6 - 330)	110
Cd	(ND - 1.2)	0.34
Cu	(19 - 89)	32
Fe	(4,900 - 75,000)	20,000
Co	(3.4 - 9.4)	5.5

	Range	Mean
Hg	(1.2 - 2.3)	1.8
Pb	(30 - 79)	62
Cd	(ND)	ND
Cu	(10 - 21)	14
Fe	(7,000 - 13,000)	9,400
Co	(3.6 - 7.0)	4.6

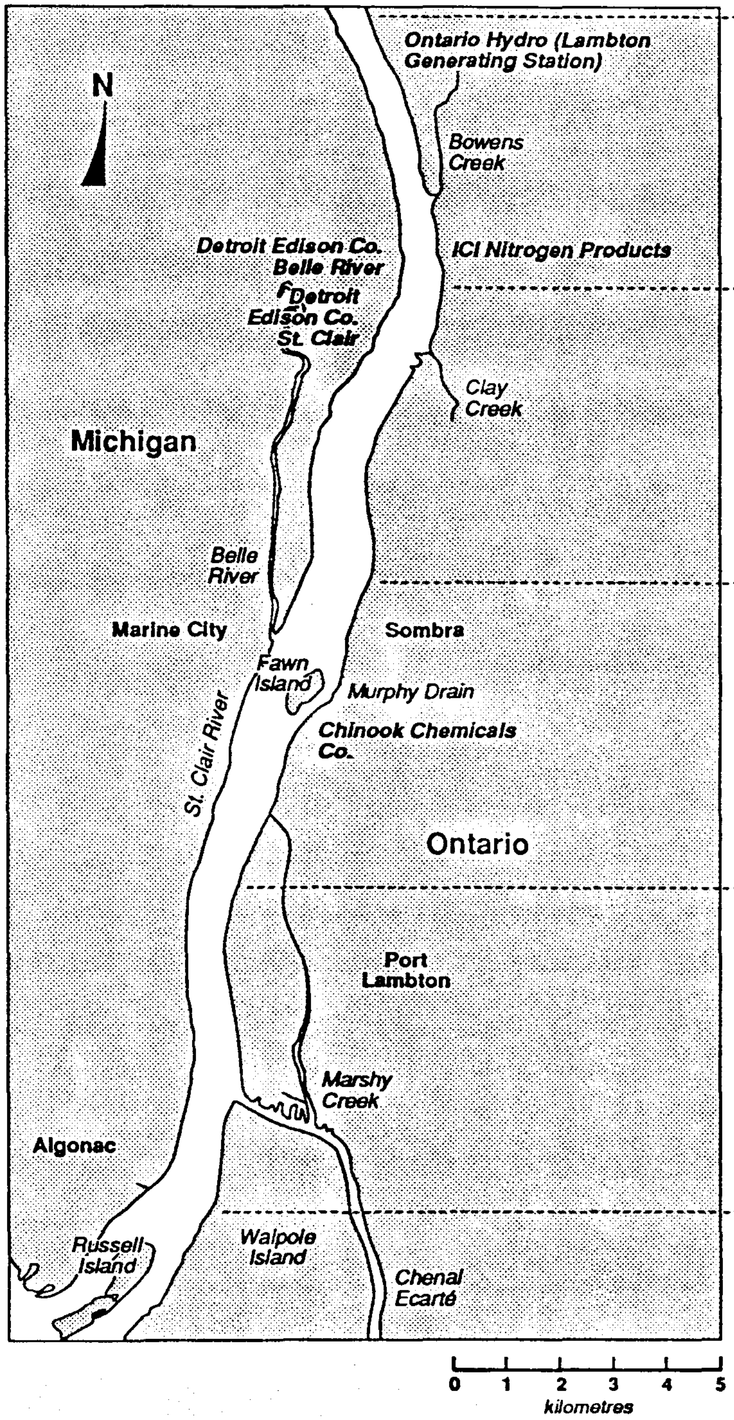
	Range	Mean
Hg	(0.88 - 1.6)	1.1
Pb	(22 - 48)	36
Cd	(ND)	ND
Cu	(16 - 24)	19
Fe	(7,800 - 21,000)	13,000
Co	(5.2 - 11)	7.2

Figure 6.14B

St. Clair River Remedial Action Plan

Means and ranges (µg/g) of metals in surficial sediments for the four lower reaches of the St. Clair River during 1985

(Oliver 1988)



	Range	Mean
Hg	(0.32 - 2.8)	1
Pb	(14 - 44)	24
Cd	(ND - 0.76)	0.19
Cu	(9.2 - 17)	14
Fe	(6,700 - 8,000)	7,300
Co	(3.0 - 4.5)	3.6

	Range	Mean
Hg	(0.51 - 0.76)	0.6
Pb	(12 - 22)	17
Cd	(0.83 - 1.1)	0.94
Cu	(12 - 17)	15
Fe	(9,500 - 13,000)	11,000
Co	(5.1 - 6.9)	5.8

	Range	Mean
Hg	(0.07 - 0.72)	0.43
Pb	(15 - 66)	28
Cd	(0.74 - 0.84)	0.8
Cu	(12 - 19)	16
Fe	(7,000 - 8,600)	7,900
Co	(4.9 - 5.5)	5.2

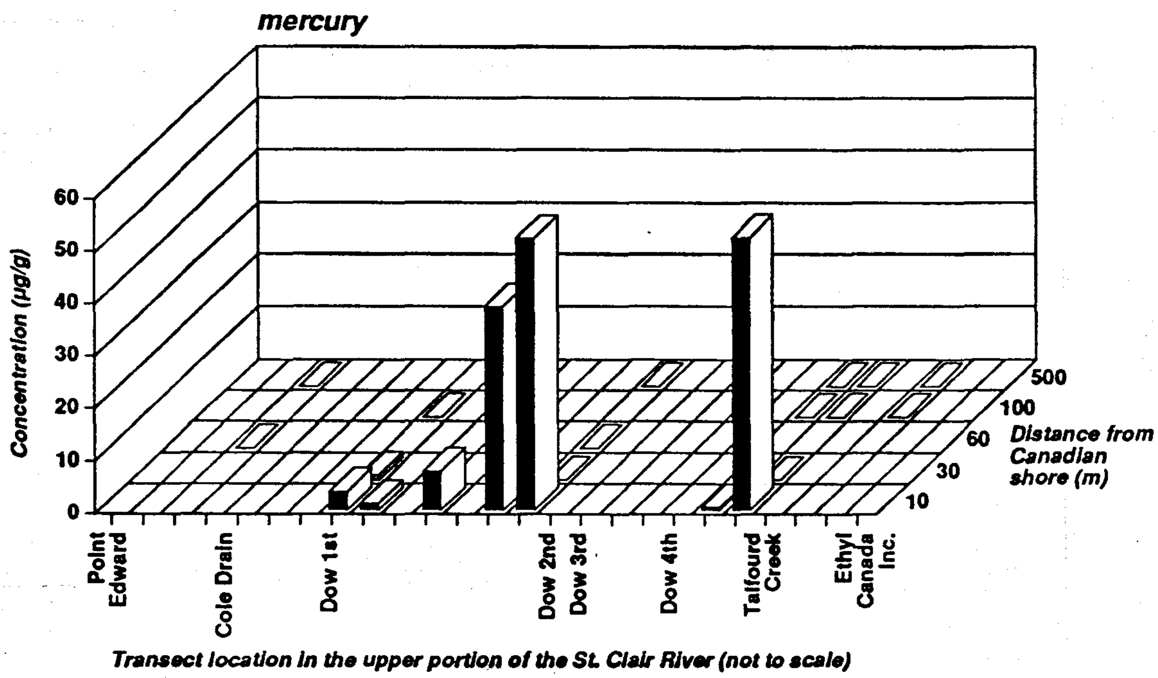
	Range	Mean
Hg	(0.23 - 0.70)	0.49
Pb	(16 - 20)	18
Cd	(0.74 - 1.8)	1
Cu	(16 - 24)	20
Fe	(8,100 - 20,000)	11,000
Co	(5.0 - 12)	6.6

Figure 6.15

St. Clair River Remedial Action Plan

Mercury and cobalt concentrations in surficial sediments collected during 1986 along transects in the upper portion of the St. Clair River

(OMOE 1990a)



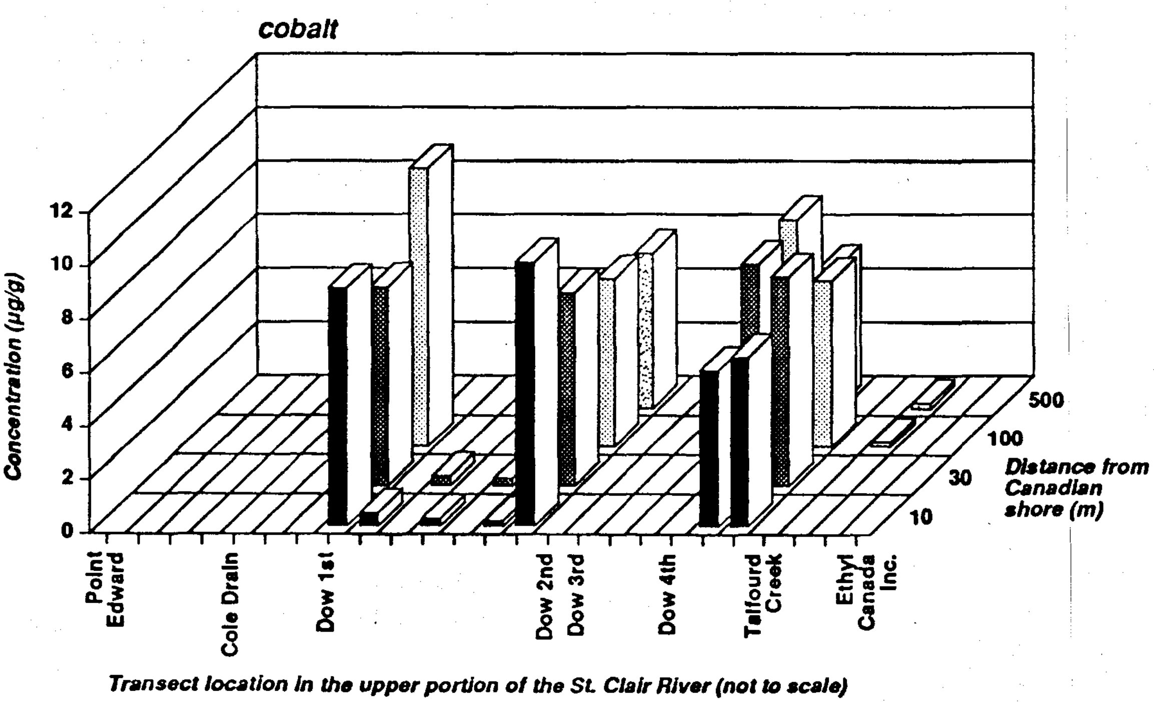
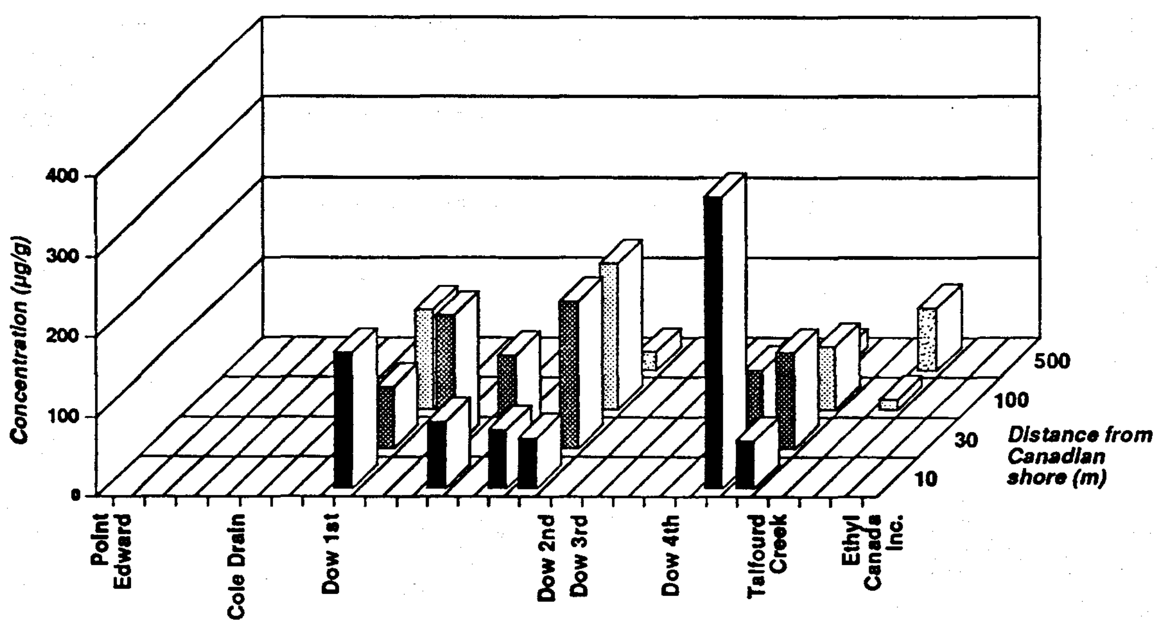


Figure 6.16

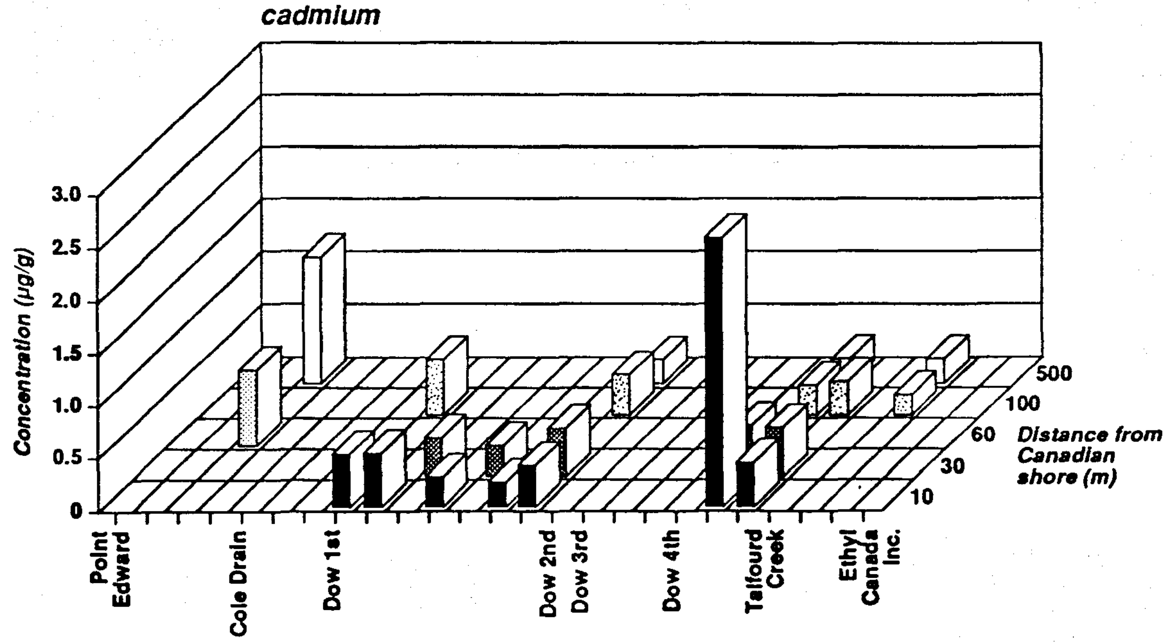
St. Clair River Remedial Action Plan

Zinc and cadmium concentrations in surficial sediments collected during 1986 along transects in the upper portion of the St. Clair River

(OMOE 1990a)



Transect location in the upper portion of the St. Clair River (not to scale)



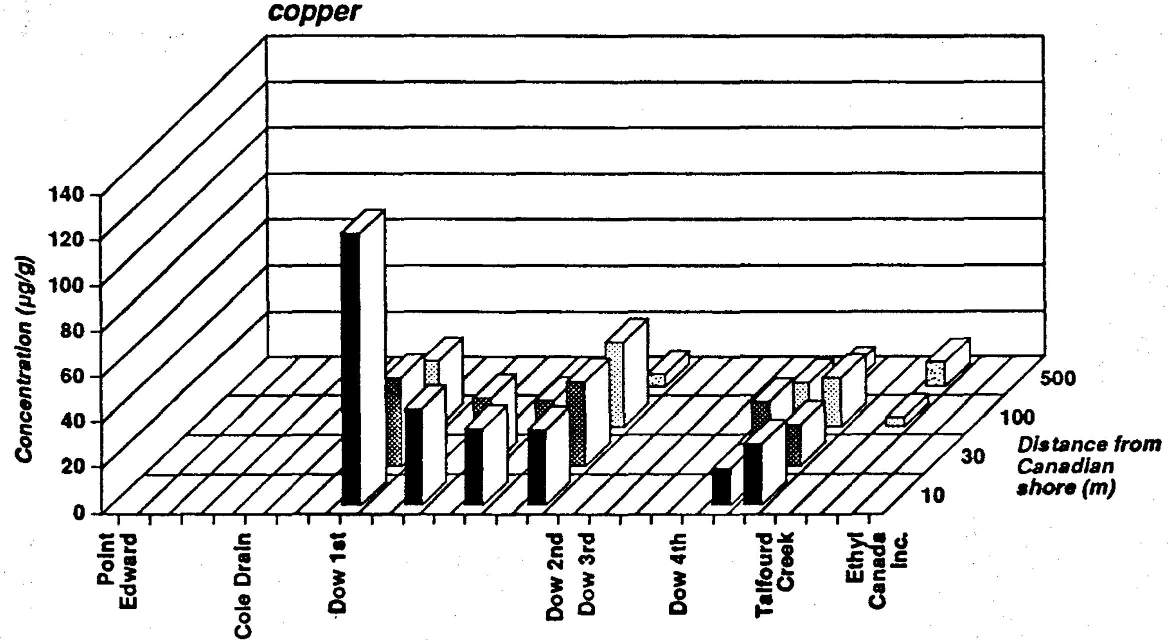
Transect location in the upper portion of the St. Clair River (not to scale)

Figure 6.17

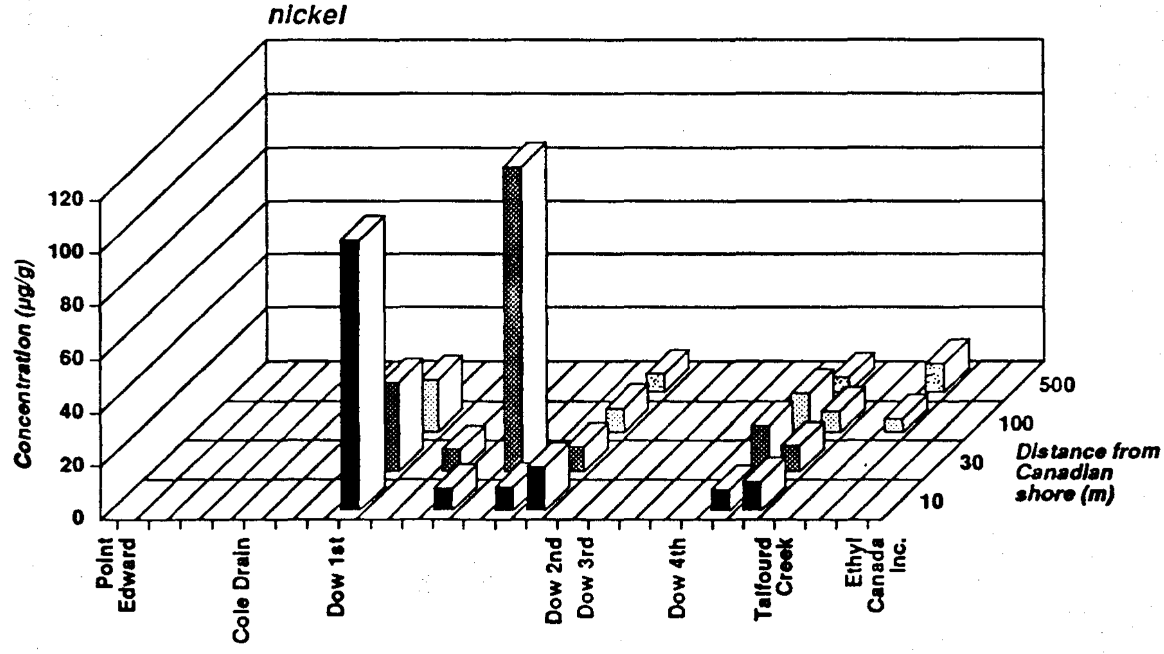
St. Clair River Remedial Action Plan

Copper and nickel concentrations in surficial sediments collected during 1986 along transects in the upper portion of the St. Clair River

(OMOE 1990a)



Transect location in the upper portion of the St. Clair River (not to scale)



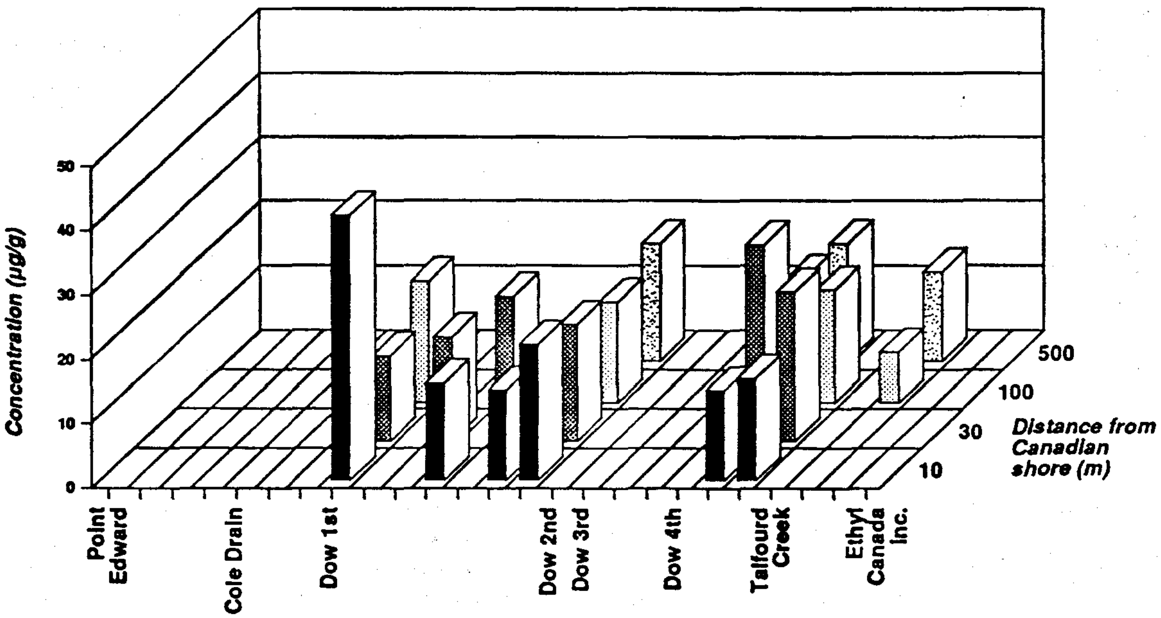
Transect location in the upper portion of the St. Clair River (not to scale)

Figure 6.18

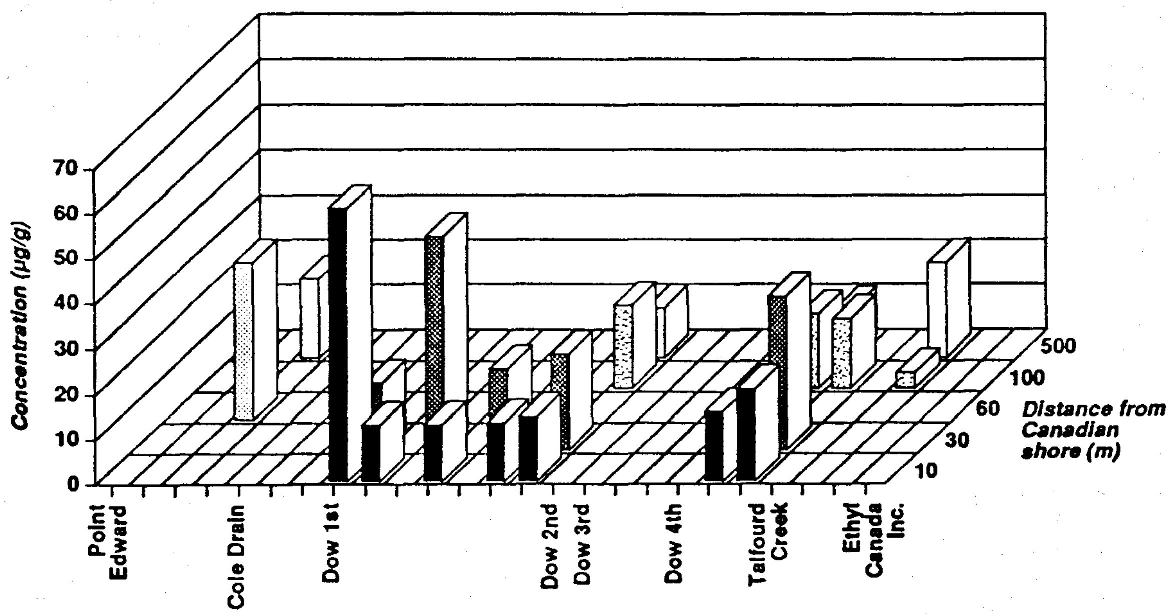
St. Clair River Remedial Action Plan

Chromium and lead concentrations in surficial sediments collected during 1986 along transects in the upper portion of the St. Clair River

(OMOE 1990a)



Transect location in the upper portion of the St. Clair River (not to scale)



Transect location in the upper portion of the St. Clair River (not to scale)

The Ontario cadmium guideline (1 µg/g) was exceeded in two of 46 samples (4%), both of which were collected from the nearshore location immediately downstream of Dow's 4th Street Sewer (2.3 and 2.9 µg/g). The U.S. EPA heavily polluted category (6 µg/g) was not exceeded.

Concentrations of cobalt were similar in all sediment samples (Figure 6.15) and were at background levels for Great Lakes' sediments (OMOE 1990a). Concentrations of aluminum and iron varied among samples more so than cobalt, however, there was no clear pattern relating to industrial or municipal sources (Appendix 6.3). OMOE (1990a) concluded that levels of these two parameters in bottom sediments represented the geochemistry of river sediments and were not attributable to contamination from local sources.

6.3.2.3 Metal Contaminants in Michigan Sediments

The U.S. Corps of Engineers 1983 St. Clair River sediment survey results are presented in Table 6.24. Results indicate that sediments along the Michigan shore as far downstream as Stag Island (Figure 6.19) did not exceed U.S. EPA interim guidelines for the disposal of Great Lakes harbor sediments, although the OMOE guideline for iron was exceeded at Station 18. Sediments in the shipping channel at Stations 14 and 15 were heavily contaminated with arsenic, iron and manganese and exceeded OMOE guidelines for arsenic, chromium (Station 14 only), iron (all stations except 13, channel; 15, flats; and 17) and nickel (U.S. Corp of Engineers 1983).

The Ontario Ministry of the Environment complete river survey of 1985 also included 23 stations along the Michigan shoreline including the U.S. portion of the delta (Appendix 6.2). Metal concentrations in these sediments were typically much lower than along the Ontario side (Oliver 1988). For example, mercury averaged 0.07 µg/g, with a high of 0.47 µg/g. Cadmium, copper and cobalt averaged 0.6 µg/g, 37 µg/g and 5.6 µg/g, respectively, with maximum observed concentrations of 2.2 µg/g, 140 µg/g and 9.5 µg/g, respectively (Appendix 6.2). The mean concentration of iron was 13,000 µg/g, with values ranging from 3,300 µg/g to 33,000 µg/g. The maximum iron concentration occurred at Station 16 (Appendix 6.2) located immediately downstream of the CN tunnel. Lead concentrations averaged only 19 µg/g over the length of the river, however, a very high value of 620 µg/g was recorded at Station 16 downstream of the CN tunnel (Appendix 6.2). The next site below this, approximately 1 km (0.6 mi) away, had a lead concentration of 69 µg/g (Station 19). These two stations are classified as heavily polluted according to the U.S. EPA interim guidelines for the disposal of Great Lakes harbor sediments and are the only stations on the Michigan shore to exceed either the moderately or heavily polluted guidelines for lead. They also exceeded the OMOE disposal guideline for lead. The mean concentration for iron, as well as 13 of 23 samples (56.5%), exceeded the Ontario dredged material guidelines for open water disposal. Only two stations exceeded the U.S. EPA iron guideline for moderately polluted sediment including the maximum value which also exceeded the heavily polluted category (25,000 µg/g). The U.S. EPA guidelines classifies the mean copper concentration as moderately polluted. A total of 13 of the 23 Michigan samples (56.5%) exceeded the moderately polluted and OMOE guidelines for copper. These occurred throughout the river as far downstream as South and Middle Channels (Stations 74 and 75, Appendix 6.2).

6.3.2.4 Nutrients

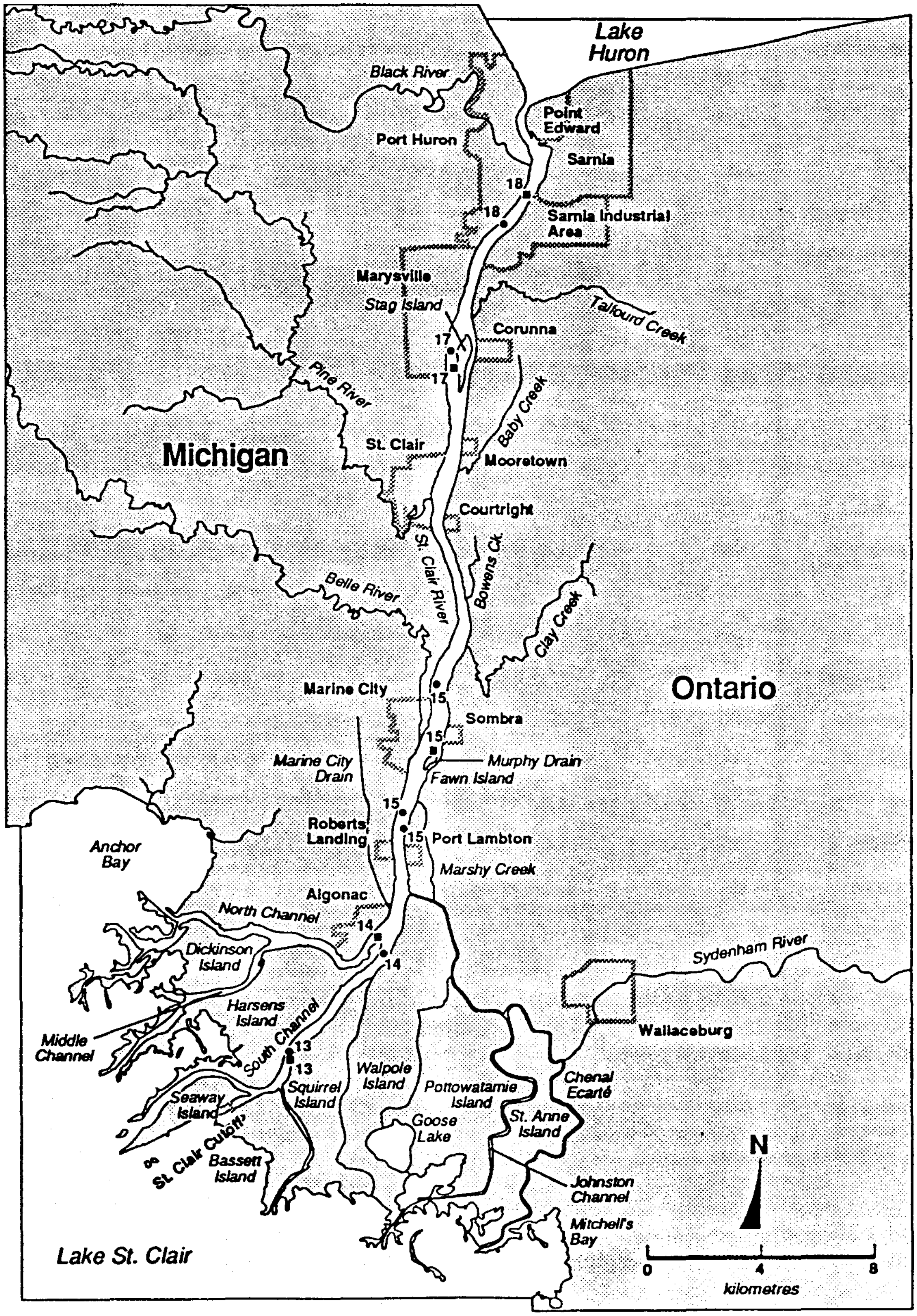
The U.S. Corp of Engineers 1983 survey (U.S. Corps of Engineers 1983) analyzed sediments for chemical oxygen demand (COD), volatile solids, ammonia, total Kjeldahl nitrogen (TKN) and total phosphorus at five locations along the St. Clair River (Figure 6.19). Total phosphorus and total Kjeldahl nitrogen data were collected as part of the 1985 complete river survey by OMOE (Oliver 1988) and again in 1986 as part of the MISA Pilot Site Investigation. Sediment from a total of 77 locations, including 23 on the Michigan side, were grab sampled in the 1985 survey. The sampling grid extended from the mouth of the river to the delta (Appendix 6.2). The 1986 MISA study sampled 23 stations between Esso Petroleum and the Lambton Generating Station (Appendix 6.3).

Figure 6.19

St. Clair River Remedial Action Plan

Location of bottom sediment samples collected for metal, nutrient and oil and grease contaminant analyses during 1983

(U.S. Army Corp. of Engineers 1983)



station

- ■ outside navigation channel
- ● within navigation channel

Table 6.24 Concentrations of metals, nutrients and selected organic contaminants in bottom sediment collections May 3 and 4, 1983 from the shipping channel ('C') and the flats outside of from the channel ('O.C.') in the St. Clair River (U.S. Corp of Engineers 1983). Values in $\mu g/g$, except for volatile solids which are reported as percentages. Sample locations shown in Figure 6.19.

Parameter	Station 13		Station 14		Station 15		Station 17		Station 18	
	C	OC	C	OC	C	OC	C	OC	C	OC
COD	500	20000	6500	18000	24000	14000	11000	3100	9400	660
oil & grease	110	510	50	310	60	210	30	130	200	360
volatile solids	1	3	2	2	3	2	2	1	2	2
ammonia	5.2	30.0	9.5	30.0	6.1	16.0	0.4	0.5	0.5	15.0
TKN	17	1400	2300	650	650	100	210	470	250	260
phosphorus	120	150	420	190	430	220	150	190	230	340
arsenic	2.3	6.0	9.4	6.3	11.0	4.1	5.4	2.7	5.9	3.8
cadmium	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
copper	2.0	19.0	22.0	12.0	19.0	9.9	4.7	2.0	9.7	11.0
chromium	6.7	13.0	32.0	13.0	18.0	13.0	9.0	8.4	11.0	16.0
iron	3200	14000	35000	12000	28000	9700	7800	5400	13000	13000
lead	3.0	28.0	15.0	12.0	8.7	25.0	3.0	3.0	5.8	12.0
manganese	53	230	530	210	340	170	150	130	210	230
mercury	0.1	0.3	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1
nickel	3.0	16.0	30.0	12.0	27.0	6.4	7.2	5.5	13.0	12.0
zinc	7.9	63.0	61.0	41.0	63.0	32.0	14.0	15.0	29.0	28.0
cyanide	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
phenols	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Overall, sediment nutrient concentrations are low and fairly consistent for both sides of the river (U.S. Corps of Engineers 1983, Oliver 1988). Total phosphorus concentrations ranged from 100 to 500 $\mu g/g$ with a mean of 230 $\mu g/g$. Total Kjeldahl Nitrogen ranged from nondetectable to 2,300 $\mu g/g$ with a mean of 420 $\mu g/g$. The U.S. EPA and OMOE total Kjeldahl Nitrogen guidelines for the disposal of dredged material (2,000 $\mu g/g$) were exceeded at only Station 14 during the 1983 survey (Table 6.24 and Figure 6.19). The 1985 complete river survey results (OMOE 1987, Appendix 6.2) indicated that all sediments from the river were of sufficient quality to meet the OMOE and U.S. EPA disposal guidelines for nutrients.

The MISA Pilot Site Investigation found comparable results for the 1986 samples in which only total organic carbon exceeded the recommended OMOE open water disposal guideline (10,000 $\mu g/g$). Total phosphorus and total Kjeldahl nitrogen concentrations were generally 3 to 6 orders of magnitude below the guidelines

(Appendix 6.3). The only exception was total phosphorus at Station 216 located near the Dow/Suncor property boundary. Concentrations of phosphorus in sediment at this station ranged from 920 to 2,300 μg/g (8 samples) exceeding both the Ontario and U.S. EPA (heavily polluted) guidelines.

6.3.2.5 Oil and Grease, PCBs, Hexachlorobenzene, Octachlorostyrene and PAHs

Bottom sediments of the St. Clair River were sampled for PCBs and oil and grease in an extensive survey conducted in 1977 by OMOE (OMOE 1979). Extensive river surveys for chlorinated organics in bottom sediments were conducted in 1984 by Oliver and Pugsley (1986), in 1985 as part of the OMOE complete river survey (OMOE 1987) and in 1986 as part of the MISA Pilot Site Investigation (OMOE 1990a). In addition, the Environment Canada/Ontario Ministry of the Environment St. Clair River Pollution Investigation included a November 1985 survey of bottom sediments in the Sarnia industrial waterfront (Environment Canada/OMOE 1986).

<u>OMOE 1977 Survey</u>

The 1977 OMOE survey (OMOE 1979) identified elevated concentrations of PCBs and oil and grease along the Ontario shoreline from the Cole Drain to the southern end of the Suncor property. PCB concentrations in this area ranged from 3 to 10 μg/g, all of which exceeded the Ontario guideline for open water disposal of PCB contaminated sediment (0.05 μg/g). Oil and grease concentrations reached a maximum of 28,000 μg/g which greatly exceeded both the Ontario and U.S. EPA disposal guidelines (1,500 μg/g). Oil globules observed in the bottom sediments were attributed to spills from industrial sources and freighters (Environment Canada/OMOE 1986).

<u>Oliver and Pugsley 1984 Survey and the OMOE 1985 Survey</u>

Figures 6.20A and 6.20B show mean concentrations and ranges of PCBs, oil and grease, hexachlorobenzene and octachlorostyrene in the Ontario sediments of nine different reaches along the St. Clair River. The figure was prepared by Oliver (1988) who combined the hexachlorobenzene and octachlorostyrene data (35 samples) from the 1984 survey of Oliver and Pugsley (1986) with the data from the 1985 OMOE complete river survey (49 samples). Data for PCBs and oil and grease are from the 1985 OMOE complete river survey only. The sample locations for the survey of Oliver and Pugsley (1986) are shown in Figure 6.21. The 1985 OMOE survey sample locations and data are provided in Appendix 6.2.

Mean values for all parameters were highest within the industrialized area south of Sarnia generally decreasing downstream. Mean hexachlorobenzene concentrations were an exception, showing an increase in reach five, which starts just upstream of Baby Creek (Figure 6.20A). The furthest downstream station reach had concentrations of hexachlorobenzene and octachlorostyrene which were much higher than near the head of the river. The wide range of concentrations within each segment of the river reflects the extreme variability of sediment contamination; this is likely due to the transitory nature and heterogeneity of sediments in the river (Oliver 1988). Even though the sediments are coarse and have low surface areas, extremely high concentrations are found along the Sarnia industrial segment, indicating very high loadings within this area (Oliver 1988).

Total PCB concentrations were also highest along the industrial waterfront south of Sarnia in 1985, decreasing downstream. Concentrations in the reach from Esso Petroleum to downstream of Suncor ranged from 0.035 to 2.6 μg/g which is less than the range noted above for 1977 (3 to 10 μg/g). The only exception to the downstream trend in 1985 was a sample collected just below Ontario Hydro's Lambton Generating Station which has an anomalously high value of 1.9 μg/g (Oliver 1988). The Ontario dredge disposal guideline for this parameter is 0.05 μg/g which is exceeded or equalled by mean concentrations in 4 of the 9 reaches. The no effect guideline for benthic use of sediment contaminated with total PCB is 0.02 μg/g (OMOE 1991a) which is exceeded in all but the furthest upstream and furthest downstream reaches.

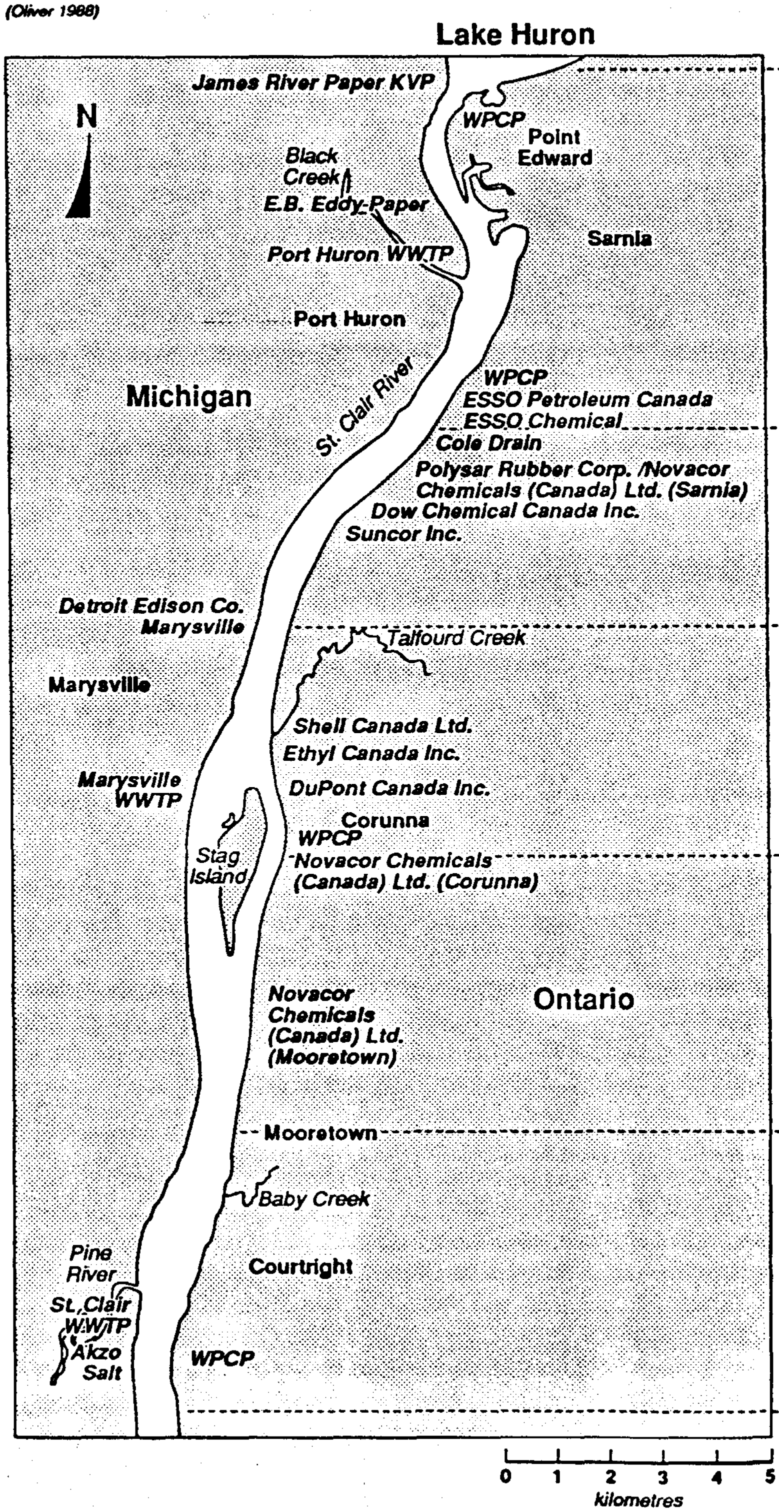
Figure 6.20A

St. Clair River Remedial Action Plan

Means and ranges (µg/g) of hexachlorobenzene (HCB), octachlorostyrene (OCS), total PCBs and oil and grease (O+G) in surficial sediments for the five upper reaches of the St. Clair River

HCB and OCS represent data collected in 1984 and 1985; data for PCBs and oil and grease were collected in 1985

(Oliver 1988)



	Range	Mean
HCB	(ND - 0.0046)	0.0011
OCS	(ND - 0.0003)	0.0001
PCBs	(ND - 0.040)	0.0130
O+G	(100 - 1,300)	800

	Range	Mean
HCB	(0.005 - 24)	3.200
OCS	(0.005 - 4)	0.770
PCBs	(0.035 - 2.6)	0.560
O+G	(750 - 5,300)	3,100

	Range	Mean
HCB	(0.014 - 1.1)	0.460
OCS	(0.004 - 0.460)	0.140
PCBs	(ND - 1.8)	0.210
O+G	(100 - 4,700)	1,600

	Range	Mean
HCB	(0.037 - 0.260)	0.160
OCS	(0.004 - 0.047)	0.033
PCBs	(0.030 - 0.090)	0.068
O+G	(360 - 670)	450

	Range	Mean
HCB	(0.021 - 1.1)	0.620
OCS	(0.004 - 0.077)	0.050
PCBs	(ND - 0.085)	0.028
O+G	(280 - 1,400)	980

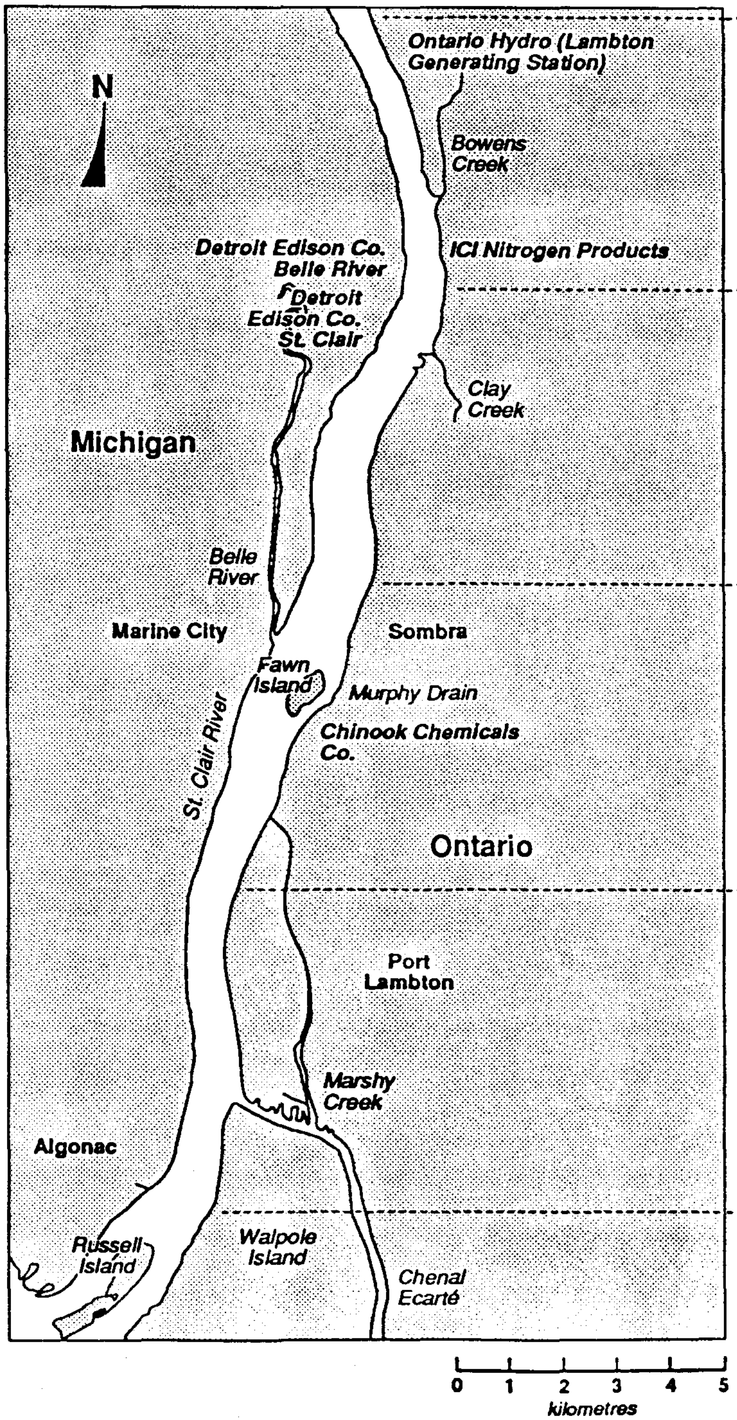
Figure 6.20B

St. Clair River Remedial Action Plan

Means and ranges (µg/g) of hexachlorobenzene (HCB), octachlorostyrene(OCS), total PCBs and oil and grease (O+G) in surficial sediments for the four lower reaches of the St. Clair River

HCB and OCS represent data collected in 1984 and 1985; data for PCBs and oil and grease were collected in 1985

(Oliver 1988)



	Range	Mean
HCB	(0.035 - 1.0)	0.340
OCS	(0.006 - 0.120)	0.048
PCBs	(ND - 1.9)	0.490
O+G	(230 - 750)	410

	Range	Mean
HCB	(0.014 - 1.0)	0.370
OCS	(0.004 - 0.230)	0.077
PCBs	(ND - 0.150)	0.063
O+G	(200 - 730)	450

	Range	Mean
HCB	(0.005 - 0.110)	0.052
OCS	(0.002 - 0.029)	0.015
PCBs	(0.030 - 0.070)	0.041
O+G	(340 - 570)	460

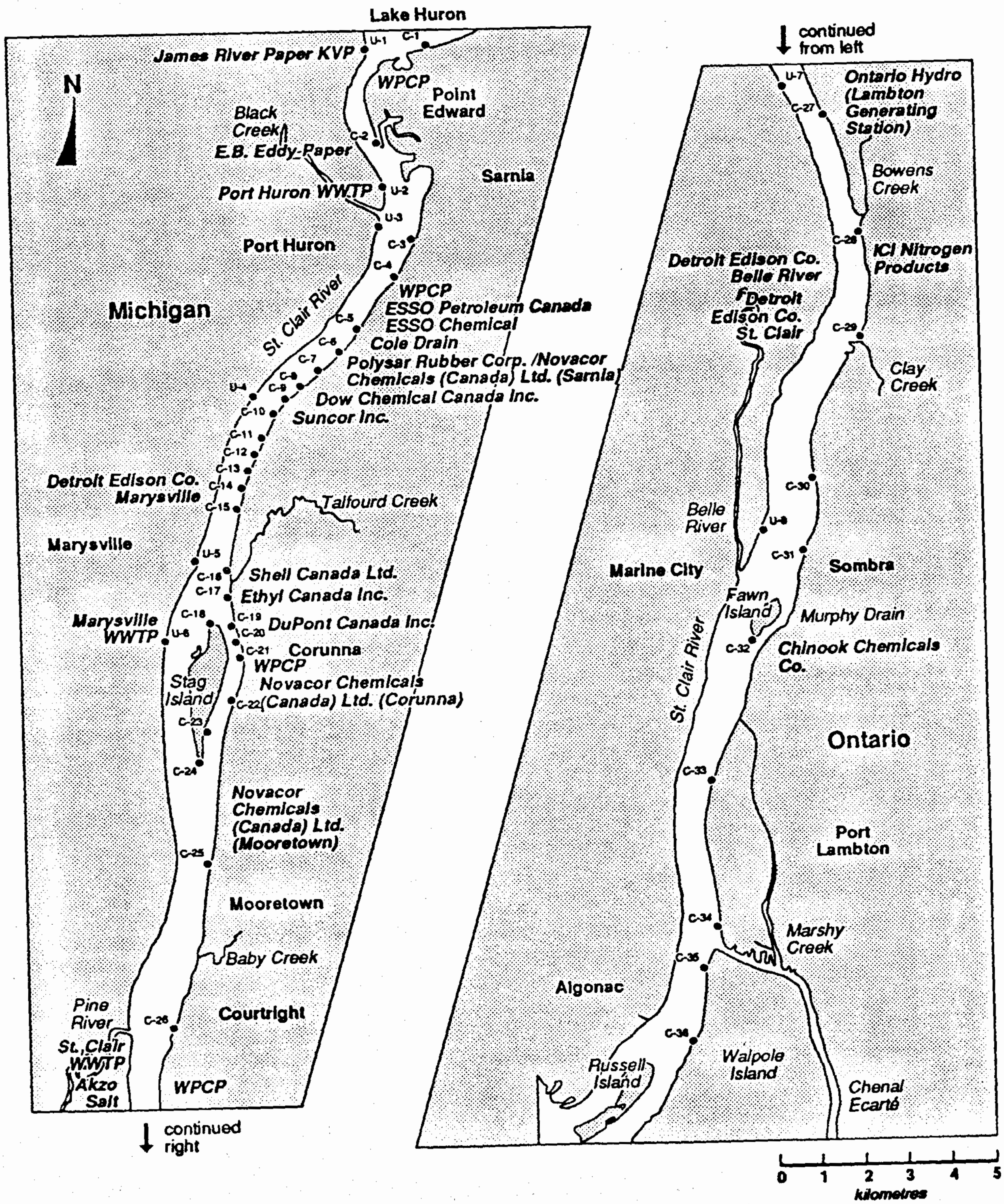
	Range	Mean
HCB	(0.016 - 0.230)	0.110
OCS	(0.005 - 0.036)	0.026
PCBs	(ND - 0.045)	0.010
O+G	(320 - 820)	620

Figure 6.21

St. Clair River Remedial Action Plan

Location of bottom sediment samples collected for organic contaminant analyses in 1984

(Oliver and Pugsley 1986)



High concentrations of oil and grease were found in 1985 along the Ontario shoreline adjacent to downtown Sarnia (2,200 µg/g and 1,300 µg/g), adjacent to Esso Petroleum (1,200 µg/g), just above Talfourd Creek (4,700 µg/g and 1,200 µg/g), just north of Corunna (2,300 µg/g and 1,100 µg/g) and below Courtright (1,400 µg/g). Mean and maximum concentrations in 1985 exceeded the Ontario and U.S. EPA disposal guidelines in the two reaches immediately downstream of Esso Petroleum (Figures 6.20A and 6.20B). However, the concentrations of oil and grease downstream of Esso Petroleum were much lower in 1985 than the maximum of 28,000 µg/g reported for the 1977 OMOE survey. Of the 54 stations located in mid-river or along the Ontario shoreline, the Ontario sediment disposal guideline for oil and grease was exceeded at a total of 10 stations and the U.S. EPA guideline for moderately polluted sediment at 15 stations (Appendix 6.2).

There are no hexachlorobenzene or octachlorostyrene guidelines for the disposal of dredged material in open water. Tentative sediment quality guidelines being prepared by the Ontario Ministry of the Environment, however, propose a 'no effect' concentration for hexachlorobenzene of 0.01 µg/g. This no effect level is based on no anticipated impact on water quality uses or benthic organisms (OMOE 1991a). All mean concentrations along the Ontario shore with the exception of the uppermost reach above Esso Petroleum, exceed this no effect concentration. A concentration of 24 µg/g (multiplied by the percentage of Total Organic Carbon in the sediment) is considered the severe effect level above which significant impairment of sediment use by benthic organisms is expected. This concentration was not exceeded in 1984/85 by mean or maximum concentrations in any river reach (Figures 6.20A and 6.20B). The mean concentration along the industrial waterfront from Polysar to below Suncor was the highest of all reaches at 3.2 µg/g.

Environment Canada 1985 Survey

An intensive sampling program of bottom sediments in the Sarnia industrialized area was conducted by Environment Canada in November 1985 (Environment Canada/OMOE 1986, Oliver 1988). The survey was designed to pinpoint sources of contamination including chlorinated organics and 16 priority PAHs. The sample stations for this survey are shown in Figure 6.22. Figures 6.23 and 6.24 show concentrations of hexachlorobenzene and octachlorostyrene in sediments at 10, 25 and 100 m (32.8, 82 and 328 ft) offshore at each station.

Low but measurable concentrations of the chlorinated organics were found at stations upstream of the Sarnia industrial complex. These concentrations reflect widespread, low-level environmental contamination from upstream disposal practices (Oliver 1988). Concentration increases observed for hexachlorobenzene and octachlorostyrene at stations 8 and 9 were attributed by Oliver (1988) to impacts from the Sarnia Water Pollution Control Plant and urban runoff. Large increases were observed at stations 10A, 10B, 10Y and 10Z where the Cole Drain enters the river. Another 'hot spot' in concentration (Oliver 1988) is observed where Dow's 1st Street Sewer complex discharges to the river (nearshore sample, station D). Chemical concentrations in the bottom sediments diminish considerably by one and two orders of magnitude at station 12 which is 300 m (984 ft) below station D.

The proposed sediment quality guideline for hexachlorobenzene is exceeded at the lowest effect level (0.02 µg/g) at all nearshore locations and most offshore locations beginning at Station 8 and continuing through Station 19. The severe effect level for sediment contaminated with this parameter (≤24 µg/g, depending on Total Organic Carbon) is exceeded by at least four stations downstream of the Cole Drain outfall; stations 10 (100 m/328 ft offshore), D (10 m and 25 m/32.8 and 82 ft offshore below Dow's 1st St. Sewer) and 25 m (82 ft) offshore at Station 14. Depending on sediment Total Organic Carbon levels, other stations may also exceed the severe effect level.

The Ontario proposed lowest effect level for hexachlorobenzene is also exceeded in bottom sediments collected at 2 stations located 25 m (82 ft) offshore on the Michigan side (stations 5B and 7B, Figure 6.23). These stations are located downstream of the mouth of the Black River and immediately upstream and

Figure 6.22

St. Clair River Remedial Action Plan

Bottom sediment sample stations for the November 1985 Environment Canada and the Ontario Ministry of the Environment Study

(Oliver 1988)

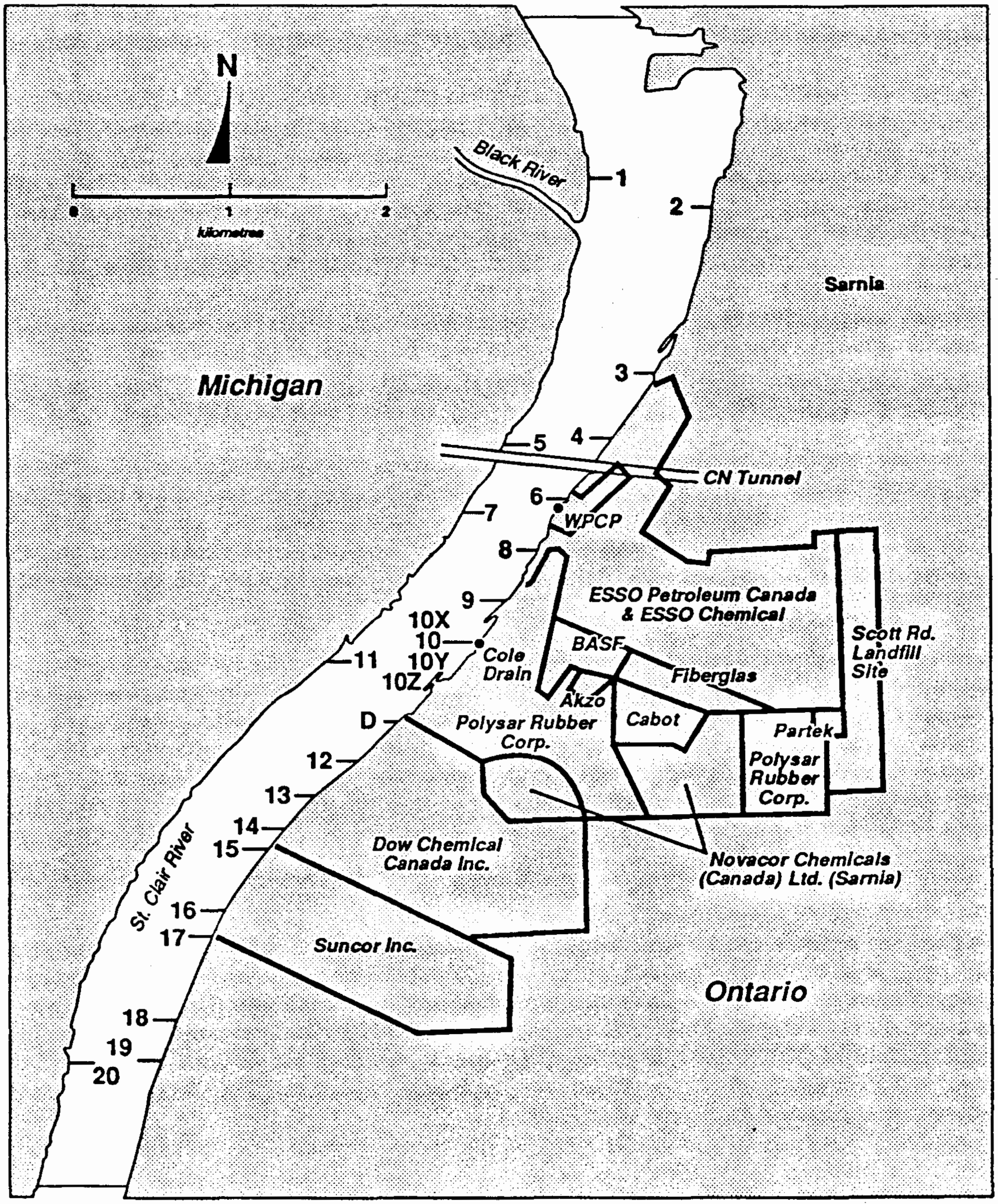


Figure 6.23

St. Clair River Remedial Action Plan

Hexachlorobenzene concentrations in surficial sediments of the upper St. Clair River, November 1985

Station locations shown in Figure 6.22

(Environment Canada/OMOE 1986)

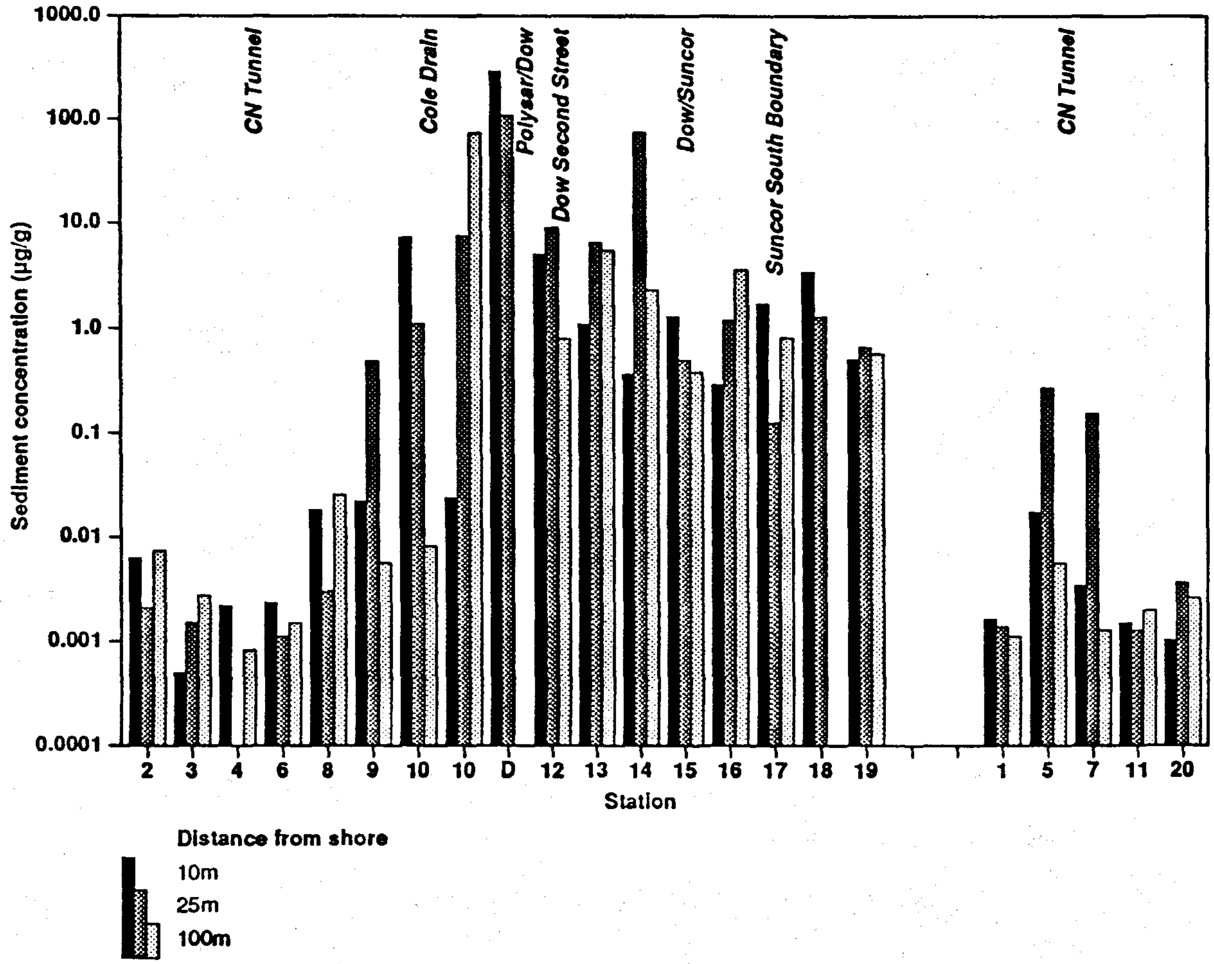


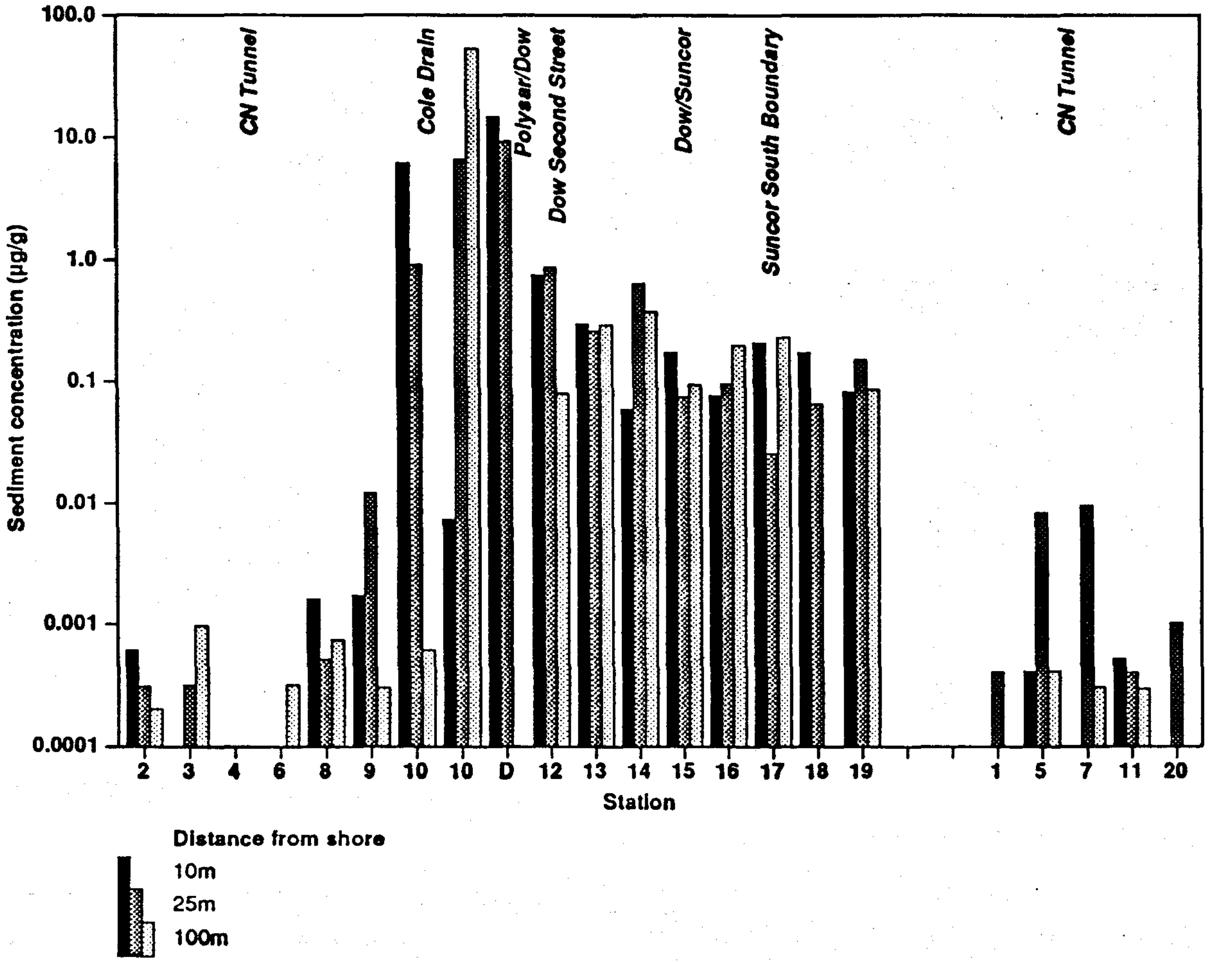
Figure 6.24

St. Clair River Remedial Action Plan

Octachlorostyrene concentrations in surficial sediments of the upper St. Clair River, November 1985

Station locations shown in Figure 6.22

(Environment Canada/OMOE 1986)



downstream of the CN tunnel. Station 1, located above the mouth of the Black River and stations downstream of Station 7 have low concentrations. The concentration pattern is similar for octachlorostyrene (Figure 6.24).

The results of the PAH analyses of samples collected during the November 1985 sampling program are shown in Table 6.25 and corresponding sample locations are shown in Figure 6.22 (Nagy et al. 1986). The sum concentration of these contaminants ranged from below detection to 60 $\mu g/g$, with an average value of 3.3 $\mu g/g$. The highest concentrations were recorded offshore of Dow at the nearshore site of Station 13 (60.79 $\mu g/g$) and the 25 m (82 ft) location of Station 14 (41.81 $\mu g/g$). On the Michigan side of the river, only 1 of 15 samples showed PAHs higher than the area average (Station 5, Table 6.25).

The Ontario nearshore (10 m/32.8 ft from shore) and intermediate (25 m/82 ft from shore) sites contained all the elevated concentrations, with a clear trend to diminishing offshore concentrations. Oliver (1988) noted the relative occurrence of two PAHs, naphthalene and fluorene, as being dominant in locations furthest offshore whereas phenanthrene dominance was confined to the nearshore zone. He interpreted this distribution to indicate that phenanthrene may be an important component of the local hydrocarbon impact. These three compounds generally comprised from 66 to 80 percent of the total PAH concentration in most samples.

No dredged material disposal guidelines exist for PAHs. However, the lowest effect level tentatively proposed by OMOE (OMOE 1991a) is 2 $\mu g/g$ and the severe effect level is 11,000 $\mu g/g$. The severe effect level was never approached by the sum of the 16 PAHs. The lowest effect level was exceeded in 12 of 60 samples, mostly at nearshore locations (Table 6.25). One exceedence occurred at the nearshore location of Station 5 on the Michigan side (above the CN tunnel). The other exceedences occurred at stations 2, 3, 10, 13, 14, 16, 17, and 18 (Table 6.25, Figure 6.22).

OMOE 1986 MISA Survey

The 1986 bottom sediment sampling program described as part of the MISA Pilot Site Investigation consisted of 23 stations located between Esso Petroleum and the Lambton Generating Station (OMOE 1990a, Appendix 6.3). Grab samples were collected at 10 m/32.8 ft offshore and varying distances up to 650 m (2,132 ft) along transects.

The highest concentration of PCBs during 1986 was found in sediments located about 150 m (492 ft) downstream of Dow's 1st Street Sewers (2.1 $\mu g/g$, Appendix 6.3). Although exceeding the Ontario disposal guideline this value was lower than the maximum reported during the 1985 OMOE survey (2.6 $\mu g/g$, Figure 6.20A) and much below the range reported for 1977 (3 to 10 $\mu g/g$). A total of 6 of the 41 (14.6%) bottom sediment samples collected during the 1986 MISA Pilot Site Investigation exceeded the Ontario disposal guideline.

The maximum concentration of oil and grease in sediments during the 1986 survey was 3,500 $\mu g/g$ found 25 m (82 ft) offshore at Station 20 located immediately downstream of the Cole Drain (Appendix 6.3). Only 2 of 41 (4.9%) of samples exceeded the Ontario disposal guideline, however, 6 samples (14.6%) exceeded the U.S. EPA lower limit for moderately polluted sediment. Concentrations during 1986 were comparable or slightly lower than found in the 1985 OMOE complete river survey.

The highest concentrations of hexachlorobenzene (228 $\mu g/g$), hexachlorobutadiene (18.7 $\mu g/g$), hexachloroethane (0.9 $\mu g/g$), octachlorostyrene (5.0 $\mu g/g$) and tri-, tetra-, and pentachlorobenzene (4.0, 0.6 and 3.08 $\mu g/g$, respectively) occurred within 100 m (328 ft) of shore at stations located between Dow's 1st and 2nd Streets Sewers (Station 206, Appendix 6.3). The overall pattern of contamination for hexachlorobenzene and octachlorostyrene are comparable to those described for the 1984 and 1985 studies summarized in Figures 6.20A and 6.20B). The maximum concentration of octachlorostyrene in 1986 was only

Table 6.25 PAHs in St. Clair River surficial sediments during 1985. Data are sum of 16 PAHs expressed as $\mu g/g$ (Nagy et al. 1986). Station locations are shown in Figure 6.22.

Transect	Distance from Shore			Average
	10 m	25 m	100 m	
1*	ND	0.58	0.08	0.22
2	1.25	1.95	2.16	1.79
3	6.81	1.06	0.76	2.88
4	0.98	0.38	0.38	0.58
5*	7.48	0.02	ND	2.50
6	0.08	0.57	0.56	0.40
7*	ND	0.36	0.90	0.42
8	ND	1.44	0.53	0.66
9	1.59	0.38	0.94	0.97
10	6.27	1.16	1.46	2.96
11*	0.82	1.56	0.44	0.94
12	1.25	0.59	0.39	0.74
13	60.79	20.13	0.50	27.14
14	2.41	41.81	0.12	14.78
15	1.12	0.92	2.64	1.56
16	4.28	0.82	0.86	1.99
17	3.32	1.52	0.69	1.84
18	3.19	1.32	ND	1.50
19	1.89	1.52	0.36	1.26
20*	0.87	0.61	0.59	0.69
Average	5.27	3.93	0.72	3.31

ND = not detected
* transects on Michigan side of St. Clair River.

slightly higher than measured within the equivalent river reach during 1984/85 (4.0 $\mu g/g$, Figure 6.20A). The maximum concentration of hexachlorobenzene, however, was almost an order of magnitude higher in the more recent 1986 survey (24 $\mu g/g$ in 1984/85, Figure 6.20A).

The hexachlorobenzene concentration in sediment at Station 206 is more than four orders of magnitude higher than the proposed lowest effect level (0.02 $\mu g/g$) and at least 10 times the severe effect level (24 $\mu g/g$). A total of 32 of the 45 samples collected (71.1%) exceeded the lowest effect level and 4 stations (8.9%) exceeded the severe effect level. Exceedences of the lowest effect level occurred at all stations downstream of the Cole Drain as far as the Lambton Generating Station.

6.3.2.6 Other Organic Contaminants

Several other organic contaminants were found in St. Clair River sediments during the 1985 surveys. Those which were noted by Oliver (1988) as having their highest concentrations immediately offshore of industrial point sources in Ontario, relative to samples collected from upstream stations (Stations 1 to 6, Figure 6.22), were:

- hexachlorobutadiene and pentachlorobenzene elevated concentrations in the sediments adjacent to and downstream of Dow Chemical and both were highly correlated with hexachlorobenzene and octachlorostyrene distributions;

- hexachloroethane;

- solvents tetrachloroethylene and carbon tetrachloride, which were the major components of the tarry material offshore of Dow in 1985, were found in very high concentrations adjacent to Dow Chemical and their presence attributed to leaks and spills from this facility;

- tetrachloroethanes, pentachloroethane, chlorobutenes, chlorobutadienes, chlorohexadienes, heptachlorostyrene and octachloronapthalene, all of which have been tentatively identified in the vicinity of Dow Chemical;

- normal alkanes, seen in sediments throughout Sarnia's industrial complex;

- diphenylether, biphenyl, 4-ethylbiphenyl and diethyl biphenyl, found at concentrations of up to 490 $\mu g/g$ in the vicinity of Sarnia's industrial complex; and

- dibenzofurans and dibenzo-p-dioxins which reached maximum concentrations of 0.11 and 0.012 $\mu g/g$, respectively, downstream of Dow's 1st Street Sewer complex (no 2,3,7,8-TCCD was found in any samples).

There are no guidelines with respect to dredged material disposal in open water or proposed sediment quality guidelines for any of the parameters listed in this section. However, they have been listed by OMOE on the Effluent Monitoring Priority List (EMPPL) which identifies those contaminants of greatest concern due to combined exposure and effects concerns.

6.3.2.7 Organic Contaminants in Michigan Sediments

Sediments along the Michigan shoreline generally contained low concentrations of hexachlorobutadiene, hexachlorobenzene and octachlorostyrene during both 1984 and 1985 (Table 6.26). The 1984 concentrations of these three parameters exceeded those of the head of the river (Station U1) near the Marysville Wastewater Treatment Plant (Station U5) as did hexachlorobenzene and octachlorostyrene at the furthest downstream location above Algonac (Station U9) (Table 6.26 and Figure 6.21). In 1985, the highest concentrations of all three parameters were found at stations 5A to 5C located immediately downstream of the mouth of the Black River (Table 6.26).

Michigan PCB concentrations in the 1985 OMOE complete river survey averaged 0.036 $\mu g/g$ (23 stations), ranging from not detected to a maximum concentration of 0.15 $\mu g/g$ (Oliver 1988). The average PCB concentration was below Ontario's guideline for the disposal of dredged material (0.05 $\mu g/g$). The highest

Table 6.26 Concentrations of hexachlorobutadiene (HCBD), hexachlorobenzene (HCB) and octachlorostyrene (OCS) in bottom sediments collected in (A) 1984 and (B) 1985 at Michigan locations along the St. Clair River (from Oliver and Pugsley 1986). Values are in $\mu g/g$ and sample locations are shown in Figures 6.21 (1984) and 6.20 (1985).

(A) 1984

	Site Number								
	U1	U2	U3	U4	U5	U6	U7	U8	U9
HCBD	ND	0.0002	0.0001	0.0002	0.0037	0.0003	0.0003	0.0008	0.0014
HCB	0.0003	0.0015	0.0004	0.0009	0.0037	0.0005	0.0003	0.0006	0.0021
OCS	ND	ND	0.0001	ND	0.0011	ND	ND	ND	ND

(B) 1985

	Site Number								
	1A	1B	1C	5A	5B	5C	7A	7B	7C
HCBD	0.0001	0.0002	0.0003	0.0006	0.0036	0.0004	ND	0.002	ND
HCB	0.0016	0.0013	0.0011	0.017	0.27	0.0057	0.0034	0.15	0.0013
OCS	ND	0.0004	ND	0.0004	0.0081	0.0004	ND	0.0093	0.0003
	Site Number								
	11A	11B	11C	20A	20B	20C			
HCBD	0.0005	0.0016	0.0002	0.0005	0.0011	ND			
HCB	0.0015	0.0013	0.002	0.001	0.0036	0.0026			
OCS	0.0005	0.0004	0.0003	ND	0.001	ND			

ND - Not Detected

concentration exceeded this guideline but was less than the EPA interim guideline (heavily polluted) for disposal of harbor sediments (10 $\mu g/g$).

A few minor 'hot spots' for oil and grease were noted by Oliver (1988) to be present during the 1985 OMOE survey. These occurred above the Blue Water Bridge adjacent to Port Huron (2,300 $\mu g/g$), above the Belle River adjacent to Marine City (2,000 $\mu g/g$) and along the North Channel downstream of Algonac (1,200 $\mu g/g$ to 1,300 $\mu g/g$). The two highest oil and grease concentrations also exceeded the Ontario guideline (1,500 $\mu g/g$). All concentrations are classified as moderately polluted according the EPA guidelines.

6.3.2.8 Chemical Sediment Profiles

Chemical sediment profiles were determined at stations 15 (25 m/82 ft offshore) and 16 (10 m/32.8 ft offshore) downstream of Dow Chemical (Figure 6.22) from cores collected in November 1985. The results are shown in Table 6.27.

Table 6.27 Concentrations ($\mu g/g$) of hexachlorobenzene (HCB), octachlorostyrene (OCS), total PAHs, oil and grease and mercury in St. Clair River sediment cores collected in November 1985. Core 15B is 25 m (82 ft) offshore from the southern property boundary of Dow Chemical and Core 16A is 10 m (32.8 ft) offshore from Suncor (from Oliver 1988).

Sediment Interval (cm)	HCB	OCS	Total PAHs	Oil & Grease	Mercury
		Core 15A			
0-3	0.5	0.074	0.9	210	--
3-6	0.15	0.028	1.2	400	--
6-9	0.078	0.016	1.4	500	--
Clay					
		Core 16A			
0-3	1.7	0.21	7.5	610	3.3
3-8	0.067	0.009	17	510	3.4
8-13	0.54	0.011	20	1,100	4.3
13-18	0.12	0.15	140	670	--
18-24	0.11	0.074	16	700	35
End of core					

Higher concentrations of hexachlorobenzene and octachlorostyrene are seen in the upper, more recent layers than in the deeper cores. The reverse behaviour was apparent for PAHs, oil and grease and mercury. Oliver (1988) explained that it is difficult to interpret sediment core data from rivers such as the St. Clair because of the dynamic nature of the sediments. However, radionuclide analyses revealed that the 0 to 3 cm (0 to 1.2 in) core section was less than 9 months old, the 3 to 13 cm (1.2 to 5 in) segments were between 1 and 10 years old, and the 13 to 24 cm (5 to 9.4 in) segments were between 10 years and 30 years old (Oliver 1988). Accordingly, the data in Table 6.27 suggest that discharges of hexachlorobenzene and octachlorostyrene to the St. Clair River increased at least up to 1985. Concentrations for PAHs, oil and grease and mercury indicate some reduction in recent loadings to the river, although discharges of these chemicals were continuing as of 1985.

Sediment cores collected from four different areas in the Chenal Ecarte, 35 to 40 km (21.7 to 24.8 mi) below the major sources were collected in 1986 by Mudroch and Hill (1989). High concentrations were found at all levels in the cores indicating that the St. Clair Delta sediments serve as a large reservoir of mercury (Table 6.28). The concentrations in all levels of 3 of the 4 cores exceeded the Ontario dredged material guideline for mercury (0.3 $\mu g/g$).

6.3.2.9 Sediment Chemical Reservoir

The total mass of chemicals in sediments along the Ontario shoreline of the St. Clair River, up to Chenal Ecarte, was estimated by Oliver (1988). For the purpose of the calculation, he assumed a uniform 10 cm (3.9 in) layer of sediment for a distance of 100 m (328 ft) from shore and a weight of sand of 1.75 g per mL of sediment.

For 1985, the approximate total mass of chemicals in Ontario shore sediment was: 41 kg (90.4 lb) hexachlorobenzene; 8.8 kg (19.4 lb) octachlorostyrene; 12 kg (26.5 lb) PCBs; 74,000 kg (163,170 lb) oil and grease; 170 kg (374.8 lb) mercury; 2,900 kg (6,394.5 lb) lead; 36 kg (79.4 lb) cadmium; 1,800 kg (3,969 lb)

Table 6.28 Mercury concentrations ($\mu g/g$) in Chenal Ecarte cores collected in 1986 (from Mudroch and Hill 1989).

Sediment Interval (cm)	Core 1	Core 2	Core 3	Core 4
0- 2	3.3	2.1	0.15	2.1
2- 4	3.7	2.5	0.17	1.0
4- 6	2.2	1.4	0.17	0.89
6- 8	1.1	1.2	0.18	1.6
8-10	1.2	1.2	--	0.98
10-12	--	1.7	--	0.67
12-14	--	1.2	--	--
14-16	--	2.0	--	--
16-18	--	1.4	--	--

copper; 870,000 kg (1.9 X 10^6 lb) iron; and 430 kg (948.2 lb) cobalt. The total mass of these 10 contaminants is 949,398 kg (2.09 X 10^6 lb). Total mass of chlorinated organics, mercury and lead is 3,132 kg (6,906.1 lb). Similar calculations were made for the Michigan shoreline, giving 0.17 kg (0.4 lb) hexachlorobenzene; 0.03 kg (0.07 lb) octachlorostyrene; 0.86 kg (1.9 lb) PCB; 29,000 kg (63,945 lb) oil and grease; 3.2 kg (7.1 lb) mercury; 860 kg (1,896.3 lb) lead; 27 kg (59.5 lb) cadmium; 1,700 kg (3,748.5 lb) copper; 590,000 kg (1.30 X 10^6 lb) iron; and 250 kg (551.3 lb) cobalt. The total mass of the 10 contaminants for 1985 is 621,841 kg (1.37 X 10^6 lb). Total mass of chlorinated organics, mercury and lead is 864 kg (1,905.1 lb).

The differences in chemical masses between the two shorelines, particularly for organics, mercury and lead, further emphasizes the importance of major Ontario sources to the AOC (Oliver 1988).

6.3.2.10 Bedload Transport of Contaminants

The significance of bedload movement to the transport of adsorbed organic contaminants in the river was determined by Oliver (1988) using chemical concentrations in water, suspended sediments and moving bedload. Bedload transport was measured at 3 locations in May 1986 with each location having 10 stations located at 50 to 70 m (164 to 229.6 ft) intervals (Table 6.29). Samples were collected using an Arnhem basket sampler.

The quantity of bedload transported in the river was found to be very small. Transport via suspended sediment was 3 orders of magnitude greater than for bedload. The bedload transport for the various pollutants amounted to less than 0.5 percent of the total contaminant loading. Clearly, bedload movement does not contribute significantly to the transport of contaminants through the St. Clair River (Oliver 1988).

6.3.2.11 Sediment Toxicity

Data on the concentration of contaminants in bottom sediments provides useful information regarding historical and ongoing pollution sources but does not provide information on the ecological impact of this contamination. The open water disposal guidelines were not developed on the basis of knowledge of impacts of specific contaminant concentrations or of synergistic characteristics of two or more parameters on the aquatic ecosystem.

Table 6.29 Comparative transport of organic contaminants in bedload and in water/suspended solids at three sites along the St. Clair River data. Calculated at a flow rate of 6,400 m^3/sec (from Oliver 1988).

Compound	Bedload		Water Plus Suspended Sediment	
	Concentration (μg/g)	Transport (g/day)	Concentration (μg/g)	Transport (g/day)
Esso Petroleum Transect				
Hexachlorobenzene	0.0061	0.004	0.000051	28
Octachlorostyrene	0.0023	0.002	0.000003	1.7
PCBs	0.016	0.011	0.00081	450
Dow Transect				
Hexachlorobenzene	0.3	0.90	0.012	6.600
Octachlorostyrene	0.072	0.22	0.0001	55
PCBs	0.052	0.16	0.00072	400
Port Lambton Transect				
Hexachlorobenzene	0.055	0.20	0.00031	170
Octachlorostyrene	0.018	0.065	0.00017	94
PCBs	0.25	0.090	0.0004	220

Sediment toxicity testing is a means to determine the potential lethal effects of contaminated sediment to native organisms.

Bottom sediments were collected in October 1986 as part of the Ontario Ministry of the Environment's In-place Pollutants Program. Samples were collected from Sarnia Bay, offshore of Polysar (Sarnia), at three locations adjacent to Stag Island, offshore of Sombra and downstream of Port Lambton (OMOE 1990a). Bioassays were conducted on fathead minnows (*Pimphales promelas*) and burrowing mayflies (*Hexagenia limbata*). The bioassays were performed in 1.5 L (0.39 U.S. gal) Mason jars with 200 mL (6.76 oz) of sediment and 800 mL (27 oz) dechlorinated tap water. The test organisms were introduced after aeration of the system and mortality was recorded daily for 21 days. The full OMOE protocol for sediment bioassay is provided in Lomas and Krantzberg (1988).

Survival of the test organisms was 100 percent in sediments from the control station at Sarnia Bay. Sediments collected downstream of Polysar (Sarnia) were acutely toxic to mayflies (14% survival) and, to a lesser extent, minnows (67% survival). Survival rates were 100 percent for minnows and between 67 and 80 percent for mayflies at stations located at the north end of Stag Island and further downstream.

The design of the study allowed an assessment of the acute toxicity of sediments to organisms which live in the sediments and in the water column directly above. Acutely lethal responses provide strong evidence that sediment contamination will adversely affect the aquatic biota native to the study site and may result in the impoverishment of benthic communities (Lomas and Krantzberg 1988). The results of the 1986 study indicate that sediments in the vicinity of the petrochemical industries were acutely toxic to both minnows and mayflies. Field observations at the time of the sediment collection revealed few benthic invertebrates. This supports the conclusion of acute lethality of these sediments and indicates that in-place sediments were having a toxic effect on a wide range of benthic species (Section 6.3.3).

The presence of visible oil in sediment has been correlated with benthic impairment (Schloesser et al. 1988). Some mortality of mayflies in downstream St. Clair River stations was attributed to the presence of visible oil in the sediments especially as no relationship was found between mortality and concentrations of metals, PCBs, pesticides, chlorophenols, octachlorostyrene or hexachlorobenzene. The contaminants responsible for the toxicity of the sediments collected offshore of the Cole Drain were not determined. The acute lethality of the sediment collected downstream of the Cole Drain was considered by OMOE (1990a) as violating the provincial policy on mixing zones. This policy states that "no conditions within the mixing zone should be permitted which are rapidly lethal to important aquatic life."

Additional sediment toxicity tests were undertaken by Pollutech (1991) for the Lambton Industrial Society during 1990. Sediment samples were collected in September and October from three control stations located in Lake Huron and the St. Clair River upstream of the industrial shoreline, as well as at six stations along Ontario's industrial waterfront. These latter stations included the Dow/Polysar property line, the Suncor/Chippewa Indian Reserve property line, between Ethyl and DuPont outfalls, between Novacor and the Corunna WPCP outfall, south of Baby Creek and immediately upstream of Sombra.

The results reported by this study indicated that:

1) Dilution water above whole sediment and elutriate water showed no toxicity to *Daphnia magna* in 48 hour static bioassay acute lethality tests;

2) Although acute toxicity to *Hyalella azteca* occurred in the 10 day static toxicity tests using whole sediment overlain with dilution water, the results are inconclusive because mortality of between 13 and 40 percent occurred in the control samples; and

3) elutriate preparations of sediment samples assayed in the Microtox toxicity test were found to be nontoxic to the test population (*Photobacterium phosphoreum*) at 90 percent elutriate concentration. 100 percent elutriate concentration could not be achieved due to the dilution factor introduced in preparing the samples (Pollutech 1991).

The results of the OMOE 1986 sediment toxicity tests can not be compared directly to those of this study due to the different species employed, the different test durations in the whole sediment tests (21 days vs 2 days), and the fact that the Pollutech study did not include resampling of the same stations utilized in the OMOE study.

6.3.2.12 Tributary Sediments

Bottom sediments were collected between April 1984 and September 1985 from the mouths of four tributaries to the St. Clair River. These included the Cole Drain, Talfourd Creek, Baby Creek and the Murphy Drain (Johnson and Kauss 1991).

Sediments from the Cole Drain were highly polluted with several organic contaminants including hexachlorobenzene and octachlorostyrene. Occasionally, concentrations of hexachlorobenzene and mercury in excess of applicable dredging and/or Ontario Sediment Quality Guidelines, as well as detectable levels of octachlorostyrene were found in the sediments of Talfourd Creek. Variable levels of hexachlorobenzene and octachlorostyrene were also seen in sediments from the Murphy Drain. Bottom sediments at the mouth of Baby Creek, which enters the river downstream of Stag Island, showed no significant contamination from organics.

Based on the data presented by Johnson and Kauss (1989), Ontario guidelines for the open water disposal of dredged material were exceeded for:

- PCBs (0.05 μg/g) in one of two samples from the mouth of Talfourd Creek (0.065 μg/g);
- mercury (0.3 μg/g) in one of two samples from the mouth of Talfourd Creek (0.76 μg/g);
- chromium (25 μg/g) in samples from Talfourd Creek (52 μg/g), Baby Creek (33 μg/g); and the Murphy Drain (49 and 61 μg/g);
- copper (25 μg/g) in one sample at the mouth of Talfourd Creek (33 μg/g);
- iron (10,000 μg/g) at the mouths of Talfourd Creek (10,000 μg/g), Baby Creek (10,000 μg/g); and the Murphy Drain (11,000 and 14,000 μg/g); and
- nickel (25 μg/g) at the mouths of Baby Creek (26 μg/g).

The above concentrations for chromium, copper and nickel result in a sediment which is classified as moderately polluted under the U.S. EPA interim guidelines for the disposal of Great Lakes' harbor sediments. Manganese concentrations at the mouth of Baby Creek (740 μg/g) are classified as heavily polluted by the U.S. EPA guidelines.

Amongst the Michigan tributaries, UGLCCS (1988, Vol. II, p. 247 to 249) reported high levels of lead (270 μg/g) and elevated levels of copper (160 μg/g) in Black River bottom sediments. At an unnamed creek across from the Lambton Generating Station, high sediment concentrations were seen for PCBs (0.076 μg/g), PAHs (0.033 μg/g), oil and grease (11,600 μg/g), lead (230 μg/g), total Kjeldahl nitrogen (6,600 μg/g) and phosphorus (1,300 μg/g). High concentrations of PCB were also seen in sediments in the Belle River (0.095 μg/g and 0.49 μg/g).

According to the U.S. EPA interim guidelines for the disposal of Great Lakes Harbor Sediments, the concentrations of lead, copper, oil and grease, total Kjeldahl nitrogen and phosphorus shown above would be classified as heavily polluted. All parameters exceed the Ontario disposal guidelines.

6.3.2.13 Sediment Quality Summary

Results of bottom sediment surveys in the St. Clair River reveal a pattern of contamination by heavy metals and industrial organics primarily from Ontario sources, including industrial and municipal facilities, urban runoff and tributaries. The most heavily contaminated portion of the river, as identified by the most frequent exceedences of disposal of dredged material guidelines, by relatively high concentrations and by sediment toxicity, is the area within 100 m (328 ft) of the Ontario shore from the Cole Drain to downstream of Suncor.

Sediment Guideline Exceedences

Exceedences of OMOE's Open Water Disposal of Dredged Material Guidelines, U.S. EPA Interim Guidelines for the Disposal of Great Lakes Harbour Sediments and the proposed Provincial Sediment Quality Guidelines in the St. Clair River AOC are summarized in Table 6.30. Contaminants which exceed Ontario's dredge disposal guidelines include total Kjeldahl nitrogen, total phosphorus, arsenic, mercury, cadmium, copper, chromium, iron, lead, nickel, zinc, oil and grease, and PCBs. Concentrations of oil and grease, arsenic, copper, iron, manganese and mercury are classified as heavily polluted by the U.S. EPA

Table 6.30 Summary of bottom sediment conditions for the St. Clair River Area of Concern.

Parameter/Factor	Guideline (μg/g)		Year and Location of Exceedence (μg/g)
Oil & Grease	Ontario DMD[1] U.S. EPA[2]	1,500 1,000-2,000	1977 -Cole Drain to below Suncor (28,000) 1985 -10 stations (Ontario DMD) and 15 stations (U.S. EPA) from Polysar (Sarnia) to Corunna (means of 1600 to 3100) 1986 -immediately below Cole Drain in 4.9% (Ontario DMD) and 14.6% (U.S. EPA) stations 1985 -Port Huron (2300) -Marine City (2000) -below Algonac (1200-1300) -tributary mouth across from Lambton G.S. (11600)
Total Phosphorus	Ontario DMD U.S. EPA	1,000 420-650	1986-8 samples near the Dow/Suncor property boundary (920-2,300;range)
Total Kjeldahl Nitrogen	Ontario DMD U.S. EPA	2,000 1,000-2,000	1983 -adjacent to Algonac (2,300; one only)
Arsenic	Ontario DMD U.S. EPA	8 3-8	1983 -adjacent to Algonac (9.4; one only) -downstream of mouth of Pine River (11; one only)
Cadmium	Ontario DMD U.S. EPA	1.0 6.0*	1985 -Polysar (Sarnia) to Corunna (range from ND to 1.4) -below ICI (range from 0.83 to 1.1) -Port Lambton to Chenal Ecarté (range from 0.78 to 1.8) 1986 -downstream of Dow's 1st St. Sewer complex (2.9/0.9; max/mean)
Chromium	Ontario DMD U.S. EPA	25 25-75	1983 -adjacent to Algonac (32; one only) 1984/85-mouths of Talfourd Ck (52), Baby Ck (33) and Murphy Drain (49 and 61) 1986 -17.5% of samples between Esso and Lambton G.S. equalled or exceeded the guideline; station downstream of Dow's 1st St. Sewer complex (37/21; max/mean)
Copper	Ontario DMD U.S.EPA	25 25-50	1984/85-mouths of Talfourd Creek (33; one only) 1985 -Polysar (Sarnia) to Corunna (means of 32 to 65, maximum 190) 1986 -57.5% of samples between Esso and Lambton G.S. equalled or exceeded; station downstream of Dow's 1st St. Sewer complex (35/17.9; max/mean); 1985 -along Michigan shore 56.5% of 23 samples (140/37; max/mean) 1985 -mouth of Black River (160)

Table 6.30 (cont'd)

Parameter/Factor	Guideline (μg/g)		Year and Location of Exceedence (μg/g)
Iron	Ontario DMD U.S. EPA	10,000 17,000-25,000	1983 -South Channel (14,000; one only) -adjacent to Algonac (12,000 - 35,000; two samples) -downstream of mouth of Pine River (28,000; one only) -downstream of mouth of Black River (13,000; two samples) 1984/85-mouths of Talfourd Ck (10,000), Baby Creek (10,000) and Murphy Drain (11,000 and 14,000) 1985 -highly variable, means or maximum concentrations exceed or meet guideline throughout river; maximum value recorded offshore of Corunna (total range for river 3700 to 75000) 1985 -along Michigan shore 56.5% of 23 samples (33000/13000; max/mean)
Lead	Ontario DMD U.S. EPA	50 40-60	1983 -below Ethyl Corp. outfall (640) 1985 -below Suncor to Corunna (330/110; max/mean) -below Sombra (maximum value of 66) 1985 -mouth of Black River (270) -tributary mouth across from Lambton G.S. (230) -Michigan shore, 2 stations downstream of CN tunnel (620 and 69)
Manganese	U.S. EPA	300-500	1984/85-mouth of Baby Creek (740; one only) 1983 -adjacent to Algonac (530; one only) -downstream of mouth of Pine River (340; one only)
Mercury	Ontario DMD U.S. EPA	0.3 1.0*	1977 -offshore of Dow (90) 1984/85-mouth of Talfourd Creek (0.76; one only) 1985 -offshore of Dow (28 to 51) -Dow/Suncor property line to 2 km (1.2 mi) below Suncor (3.3 to 4.3) -Cole Drain to below entrance to Chenal Ecarté (means decreasing through river reaches from 9.2 downstream to 0.43) 1986 -station downstream of Dow's 1st St. Sewer complex (7.6/2.6; max/mean) -26 samples between Esso Petroleum and Lambton G.S.exceeded Ontario guideline, 20 exceeded U.S. EPA guideline -surficial layers in 3 of 4 cores from the Chenal Ecarté (2.1 to 2.3)
Nickel	Ontario DMD U.S. EPA	25 20-50	1983 -adjacent to Algonac (30; one only) -downstream of mouth of Pine River (27; one only) 1984/85-mouth of Baby Creek
Zinc	Ontario DMD U.S. EPA	100 90-200	1986 -42.5% of samples between Esso and Lambton G.S.; station downstream of the 1st Street Sewer complex (690/137; max/mean)

Table 6.30 (cont'd)

Parameter/Factor	Guideline (µg/g)		Year and Location of Exceedence (µg/g)
PCBs	Ontario DMD U.S. EPA	0.05 10.0*	1977 -Cole Drain to southern end of Suncor (3 to 10) 1984/85-mouth of Talfourd Creek (0.065; one only) 1985 -Polysar/Cole Drain to downstream of Allied Chemical (means for three river reaches 0.56 decreasing downstream to 0.068) -below ICI to Sombra (mean 0.063, range ND to 0.15) 1986 -14.6% of samples between Esso and Lambton G.S.
PAHs	Ontario SQ[3]	2.0	1985 -along industrial waterfront and just south of Sarnia Bay (60.79/3.3; max/mean) -nearshore downstream of mouth of Black River (7.48; one only)
Hexachlorobenzene	Ontario SQ	0.02	1984/85-all 8 river reaches downstream of Cole Drain (means range from 3.2 decreasing downstream to 0.052) -mouths of Cole Drain and Talfourd Creek (?) 1985 -Sarnia WPCP to about 1.5 km (0.9 mi) south of Suncor (nearshore samples range from 0.01 to > 100) 1986 -71.4% of samples above lowest effect level and 8.9% of samples exceeded severe effect level between Dow and Lambton G.S.; station 200 m (656 ft) downstream of Dow 1st Street Sewer complex (228)
Sediment Toxicity	Acute Lethality[4]		1986 -downstream of Cole Drain (*Pimphales promelas* 67% survival rate; *Hexagenia limbata* 14% survival rate)

[1] Ontario Ministry of the Environment Guidelines for the Dredged Material Disposal in Open Waters.
[2] U.S. EPA Interim Guidelines for the Disposal of Great Lakes Harbour Sediments - values shown are ranges encompassing the 'Moderately Polluted' classification, values above the maximum noted are in the 'Heavily Polluted' class.
[3] Ontario Proposed Sediment Quality Guidelines, Lowest Effect Level (OMOE 1991a).
[4] Ontario Mixing Zone Policy (OMOE 1984).

* heavily polluted category only, moderately values are either not determined (Hg and Cd) or to be calculated on a case-by-case basis (PCBs).

interim guidelines for the Disposal of Great Lakes harbour sediments whereas chromium and nickel are moderately polluted. Hexachlorobenzene and total PAHs exceeded the lowest effect level of Ontario's proposed sediment quality guideline.

Iron exceeded Ontario and EPA dredge disposal guidelines in several locations in the river but no pattern relating to point or nonpoint sources in the area of concern could be identified.

Sediments on the Michigan side of the river are generally much less polluted than those on the Ontario side. Mean concentrations of copper and iron from 23 stations along the Michigan shore exceed the Ontario open water disposal of dredged material guidelines. The mean copper concentration is also classified as moderately polluted by the EPA interim guidelines for the disposal of Great Lakes harbor sediments. Two sites immediately downstream of the CN tunnel had concentrations of lead which exceed the Ontario disposal guideline and are classified as heavily polluted by the U.S. EPA interim guideline. Maximum iron concentrations in sediment along the Michigan side of the river (33,000 $\mu g/g$) are also classified as heavily polluted. Sediments in the lower river, downstream of the mouth of the Pine River, exceeded OMOE guidelines for arsenic, chromium, iron and nickel and were classified as heavily polluted by the U.S. EPA guidelines for arsenic, iron and manganese during 1983. Oil and grease concentrations in sediment of the North Channel, adjacent to Port Huron and adjacent to Marine City were classified as moderately polluted by the EPA interim guidelines.

Elevated Concentrations of Parameters in Sediments

Other parameters found in sediments at high concentrations, relative to sediments upstream of the Sarnia industrial area, and attributed to Ontario sources but either not exceeding guidelines or for which no guidelines are available include zinc, oil and grease, phenanthrene, hexachlorobutadiene, octachlorostyrene, tri-, tetra- and pentachlorobenzene, hexachloroethane, tetrachloroethylene, carbon tetrachloride, tetrachloroethanes, pentachloroethane, chlorobutenes, heptachlorostyrene, octachloronapthalene, alkanes, diphenylether, biphenyl, 4-ethylbiphenyl and diethyl biphenyl, dibenzofurans and dibenzo-p-dioxins.

The pattern of PCB contamination of bottom sediments is not as consistent as for the other parameters. Anomalously high values have been recorded in sediment offshore of the Lambton Generating Station and in Michigan tributaries.

Organic contaminants found in sediments on the Michigan side of the river included hexachlorobutadiene, hexachlorobenzene and octachlorostyrene. Concentrations of these parameters in sediments immediately downstream of the mouth of the Black River (Stations 5A - 5C, Table 6.26) were elevated above those from the St. Clair River upstream of the mouth of the Black River (Station 1A - 1C, Table 6.26). These three parameters also occurred at concentrations in sediment during 1984 which were elevated relative to upstream stations (Station U1, Table 6.26) in the vicinity of the Marysville WWTP (Station U5, Table 6.26).

Historical Trends in Sediment Contamination

Sediment cores from the St. Clair River downstream of the Dow 1st Street outfall show a pattern of declining concentrations of PAHs, mercury and oil and grease up to 1985. Mercury concentrations in surficial sediments offshore of Dow, for example, have declined from a high of 90 $\mu g/g$ since the early 1970s to 52 $\mu g/g$ in 1986 (OMOE 1990a). Similarly, maximum lead concentrations in sediment downstream of the Ethyl Corporation outfall have declined from 640 $\mu g/g$ in 1983 to 330 $\mu g/g$ in 1985. Oil and grease concentrations downstream of Esso Petroleum have declined from maximum values of 28,000 $\mu g/g$ in 1977 to between 750 and 5,300 $\mu g/g$ in 1985 and 86 to 3,500 $\mu g/g$ during 1986. PCB concentration ranges in the river reach between Esso Petroleum and Suncor declined from 3 to 10 $\mu g/g$ in 1977 to 0.035 to 2.6 $\mu g/g$ in 1985 and below detection to 2.1 $\mu g/g$ in 1986. Although differences in analytical and sampling methodology may affect the results, there appears to be a trend of declining concentrations of mercury, lead, PCBs and oil and grease in bottom sediments of the St. Clair River.

In contrast, higher concentrations of hexachlorobenzene and octachlorostyrene in surficial layers of cores suggest continued high loadings, at least up to 1985.

6.3.3 Biota Quality

In reviewing studies conducted between 1968 and 1985, the UGLCCS (1988, Vol. II, p. 238) concluded that formerly impaired biological communities of the St. Clair River (phytoplankton, wetlands, submerged macrophytes, benthic invertebrates and fish) have increased in productivity. These improvements have occurred primarily along the Ontario shore, downstream of Sarnia. Further improvements to biological components within the AOC can be made.

The biota of the river and its environs consist of diverse assemblages of species (Chapter 5). A wide range in physical conditions associated with riverine, wetland and upland areas, particularly in the delta, create a mix of substrates for colonization by aquatic macrophytes, benthic invertebrates and terrestrial vegetation. This in turn provides spawning and nursery habitats for fish as well as nesting, staging and feeding areas for a large number of wildlife species.

6.3.3.1 Phytoplankton

Primary producers of the St. Clair River consist of phytoplankton, emergent and submersed macrophytes and the periphyton community, which grows attached to the river's substrate or to submerged portions of aquatic macrophytes (UGLCCS 1988).

6.3.3.1.1 Trophic Status

Mean annual phytoplankton densities at the Lambton Water Treatment Plant (WTP) intake located at the head of the St. Clair River (Figure 6.3) were determined for the period from 1984 to 1989 (Table 6.31). Density of phytoplankton is expressed as Areal Standard Units (A.S.U.) per volume of water, where 1 ASU = 400 sq. microns of phytoplankton. The average value for this period is 352 areal standard units (A.S.U./mL) with annual means ranging from 189 to 436 A.S.U./mL. Based on the trophic classification system of Michalski (1975), water entering the St. Clair River ranges from slightly mesotrophic (≥400 A.S.U./mL) to oligotrophic (<400 A.S.U./mL).

Table 6.31 Phytoplankton densities in raw water samples collected at the Lambton Water Treatment Plant, 1984 to 1989. Values are annual means of weekly samples expressed in Areal Standard Units/mL (from OMOE data files).

Year	Phytoplankton Densities	
	Mean	Range
1984	408	101 - 827
1985	419	139 - 939
1986	255	94 - 441
1987	189	38 - 467
1988	407	169 - 926
1989	436	61 - 931

Phytoplankton densities averaged 686 A.S.U./mL over the period 1966 to 1970 (Hopkins 1976) and 476 A.S.U./mL over the period 1976 to 1981 (Hopkins 1983). The mean value for the most recent period is almost one half that of the 1966 to 1970 period. These data indicate a strong trend from mesotrophic to oligitrophic conditions. The reasons for this are uncertain.

6.3.3.1.2 Contaminants

There is virtually no historical data on contaminants in phytoplankton of the St. Clair River. Phytoplankton were sampled as part of the St. Clair River MISA Pilot Study (OMOE 1990a). Samples were collected 10 m (32.8 ft) offshore at three locations during July 1986. Stations, from upstream to downstream, were located off Esso Petroleum, Dow Chemical and Suncor Inc.

Parameters measured included chlorinated organics: 1,4-dichlorobenzene; 1,2-dichlorobenzene; hexachloroethane; 1,2,4-trichlorobenzene; hexachlorobutadiene; pentachlorobenzene; hexachlorobenzene; octachlorostyrene; and total PCBs; as well as the pesticides α-BHC and DDE. Elevated concentrations (relative to the other stations) occurred in the smaller fractions of samples collected offshore of the Dow outfalls for all parameters except DDT (Table 6.32). Of the coarser size fraction, only DDT, DDE, α-BHC and octachlorostyrene had higher concentrations at stations other than at Dow.

Table 6.32 Contaminants found in Phytoplankton samples obtained from the St. Clair River - July 30, 1986 (OMOE 1990a). Station numbers correspond to those shown in Figure 6.6.

Parameter μg/g (dry weight)	Station					
	202 (Esso Petroleum)		204 (Dow Chemical)		18 (Suncor)	
	<20μm	>20μm	<20μm	>20μm	<20μm	>20μm
1,4-Dichlorobenzene	38.0	-	1600	500	420	-
1,2-Dichlorobenzene	-	-	-	210	81	-
Hexachloroethane	0.9	21	120	57	12	22
1,2,4-Trichlorobenzene	22	27	120	28	37	27
Hexachlorobutadiene	-	72	670	550	200	360
Pentachlorobenzene	6.5	-	81	62	35	47
Hexachlorobenzene	6.4	53	1400	2700	420	1300
α - BHC	7.5	12	18	3	12	2
Octachlorostyrene	7.2	18	820	100	290	610
PCB (Total)	340.0	460	3000	800	1100	640
DDT	7.5	-	3.9	4.6	13	13
DDD	-	-	-	-	27	22
DDE	17	28	75	15	31	29

- data not available

Higher concentrations of chlorinated organics in phytoplankton offshore of Dow Chemical relative to upstream and downstream stations suggest they are impacted by sources from Dow. However, the database for phytoplankton is very limited and not conclusive (OMOE 1990a). Concentrations of PCBs, octachlorostyrene, hexachlorobenzene, pentachlorobenzene and hexachloroethane in bottom sediment and water were also found to be elevated in this area (Sections 6.3.1 and 6.3.2). The pattern of pesticide concentration confirms the results of Chan and Kohli (1987) indicating that pesticides in water are not attributable to local St. Clair River sources but reflect more widespread contamination (Section 6.3.1).

6.3.3.2 Benthic Macroinvertebrates

6.3.3.2.1 Biomass and Productivity

The biomass of benthic macroinvertebrates for the St. Clair system (including both the river and lake) was estimated to average 1.33 g/m^2 in 1983-84 (Hudson et al. 1986). This is comparable to that of the St. Lawrence River (1.4 g/m^2, Mills et al. 1981) and equal to or higher than the mean values of 6 of 8 rivers listed by Barton and Smith (1984).

Productivity (per unit area) of macroinvertebrate fauna in the St. Clair River (including the delta) has been estimated at 7.4 g ash-free dry weight/m^2/year (Griffiths et al. 1991). This is somewhat greater than estimates for Lake St. Clair excluding the delta (6.8 g/m^2/year), or the Detroit River (5.4 g/m^2/year), but considerably less than that of the St. Lawrence River (13.4 g/m^2/year). There is some evidence to suggest that productivity increases from the St. Clair River's head to its mouth (Griffiths et al. 1991).

The population density of benthic macroinvertebrates, especially in the lower river and delta, is high. Based on 1977 data, the average density of the total of 15 taxa in the lower river/delta was 13,243 organisms/m^2 (see Chapter 5 and Table 18 in Herdendorf et al. 1986). By comparison, benthic macroinvertebrate densities in the open waters of Lake St. Clair and the shallower waters of Anchor Bay during the same year was estimated to average only 4,355 organisms/m^2 and 7,665 organisms/m^2, respectively.

6.3.3.2.2 Importance of Benthic Invertebrates for Contaminant Studies

Benthic invertebrates, particularly the clams, mussels and aquatic insects (mayflies, caddisflies), are important organisms with regard to identifying impacts and effects of navigation-related developments, such as dredging and infilling, and toxic contaminants (Edsall et al. 1988a). They have been the focus of numerous studies from impacted areas throughout the Great Lakes including the St. Clair River. The benthic macroinvertebrates of the St. Clair system have been studied extensively by OMOE (1979), Hiltunen (1980), Thornley (1985), Chau et al. (1985), Oliver and Bourbonniere (1985), Hudson et al. (1986), Environment Canada/OMOE (1986), Griffiths (1989), Griffiths et al. (1991) and OMOE (1990a). According to OMOE (1990a), benthic invertebrates are recognized for their value as indicators of environmental quality because they:

a) are abundant in most aquatic habitats;
b) are readily collected and identified;
c) show a wide range of tolerances to various degrees and types of pollutants;
d) generally remain in a localized area because of their restricted mobility and habitat preference; and
e) are continuously subjected to the full rigor of the local environment throughout their aquatic life cycle.

Data on benthic invertebrate health as evidenced by either community structural changes (dominant species, community assemblages) or measured chemical body burdens reflect the integrated effects of all environmental variables during their life cycle within any given habitat. Thus, the benthic invertebrate fauna can be used to directly measure the effects of environmental stresses on aquatic systems, whereas water and sediment quality data indicate the concentrations of contaminants at a point-in-time (OMOE 1990a).

The relationships between benthic fauna and sediment contaminant levels are particularly important in determining the potential for impacts to aquatic systems. These relationships are studied in two ways: sediment toxicity testing and bioaccumulation.

In the case of sediment toxicity tests (discussed in Section 6.3.2), organisms collected from noncontaminated control locations, or cultured in laboratories, are placed in containers with measured amounts of sediment. The sediment is collected from areas of interest to the study and, for the purposes of source identification, should include samples from stations located upstream, downstream and adjacent to outfalls or other potential sources. Sediment acute or chronic toxicity, over some period of time, is then measured.

Bioaccumulation, on the other hand, involves the retention of contaminants in tissue of benthic fauna living in or on the sediment. The bioaccumulation of any given contaminant can be expressed as the bioconcentration factor (BCF); i.e., the ratio of concentrations between the biological material and the sediment. Statistically significant correlations between the level of a given contaminant in the biota and in the sediment the biota was living in, is interpreted to indicate that the sediment is the most likely source of the contaminant uptake in the organism. The identification of variations and patterns in the BCF relative to potential sources of contamination is an important tool to determine the likely source of the contamination. If statistically significant correlations do not occur, then other factors such as exposure to other media (i.e., water), physio-chemical interactions and/or complex physiological processes must be considered as being significant input to the total BCF. The process of bioaccumulation thus often varies among species for any given contaminant and among contaminants for any given species. It is also affected by sediment characteristics such as the amount of organic matter in the sediment.

The importance of body burdens of specific chemicals or combinations of chemicals to the mortality of the organism or to its overall health is poorly understood for most parameters and most species. Most of the work to date is based on studies involving PCBs. In a laboratory experiment, exposing an amphipod (*Hyalella azteca*) to PCBs (Aroclor 1242), Borgmann et al. (1989) found that body burden was a better indicator of toxicity than levels in the environment (water, in this case). Toxic effects occurred at tissue levels of between 30 and 180 $\mu g/g$ wet weight. Similarly, Duke et al. (1970) and Nimmo et al. (1974) first observed toxic effects of PCBs in the shrimp (*Palaemonetes spp.*) above concentrations of 18 to 24 $\mu g/g$ wet weight; and Nebeker and Puglisi (1974) found that reproduction of the amphipod (*Gammarus pseudolimnaeus*) stopped between body burdens of 76 and 315 $\mu g/g$ wet weight.

6.3.3.2.3 Contaminant Impacts on Benthic Community Structure

Community Changes, 1968-1977

The structure of benthic macroinvertebrate communities is often used as an indicator of environmental quality. Many benthic organisms are intolerant of sediment contamination or reduced oxygen conditions, while other organisms thrive in such situations. Thornley (1985) compared the macrozoobenthos of the St. Clair River between 1968 and 1977. The location of sampling stations on the Canadian side of the river were identical for both surveys and are shown in Figure 6.25. The study divided the river into four zones, with several samples being collected along both the Michigan and Ontario shorelines providing a total of eight areas (Figure 6.26).

In both 1968 and 1977, the community along the Michigan shore was well-balanced (i.e., well-represented by pollution intolerant, facultative and tolerant organisms), and was essentially unaltered spatially. Both the number of taxa and density of organisms were high. The community was not impaired. No explanation was

Figure 6.25

St. Clair River Remedial Action Plan

Biological sampling locations (1968 and 1977) in relation to industrial and municipal point sources

(OMOE 1979)

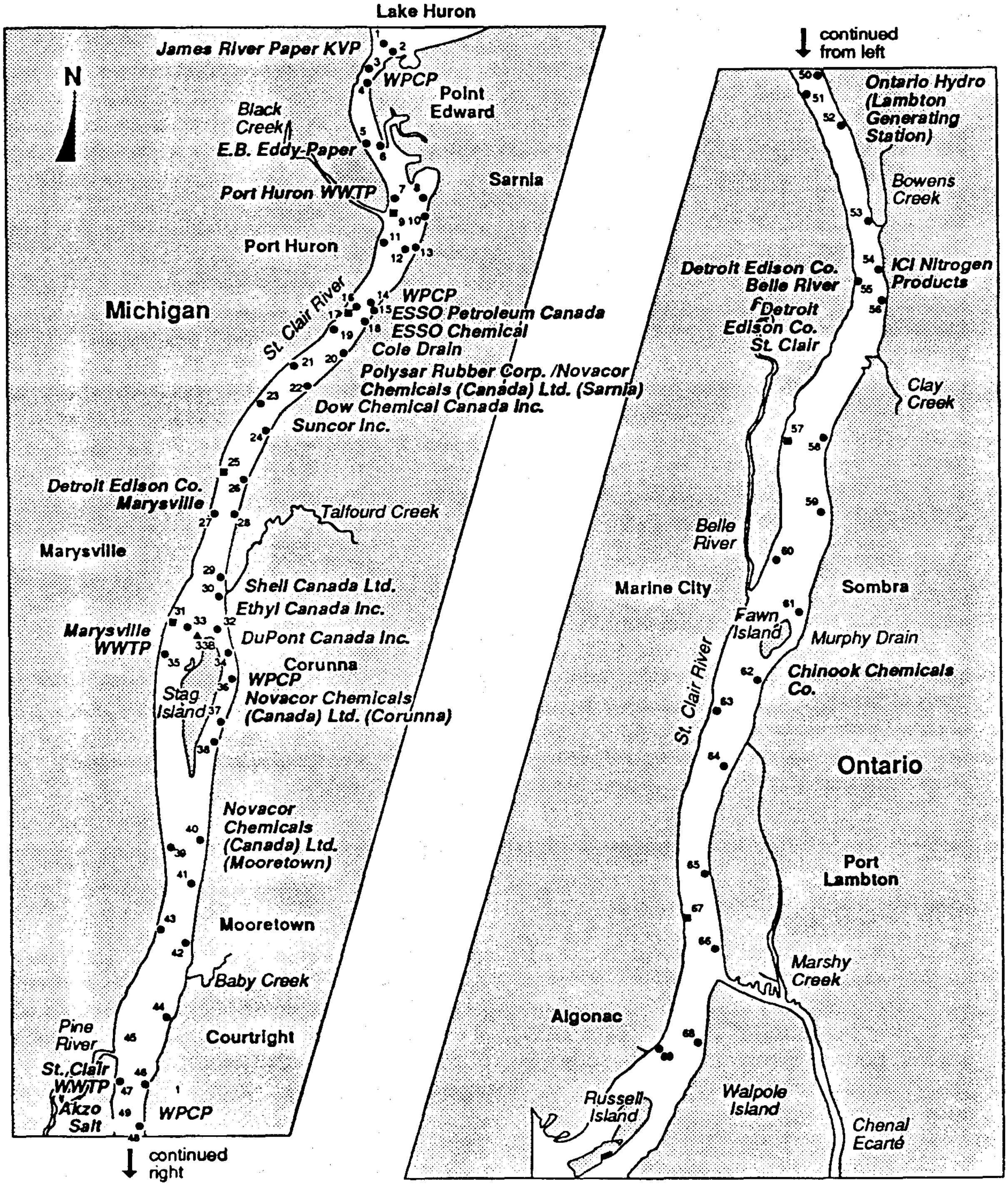
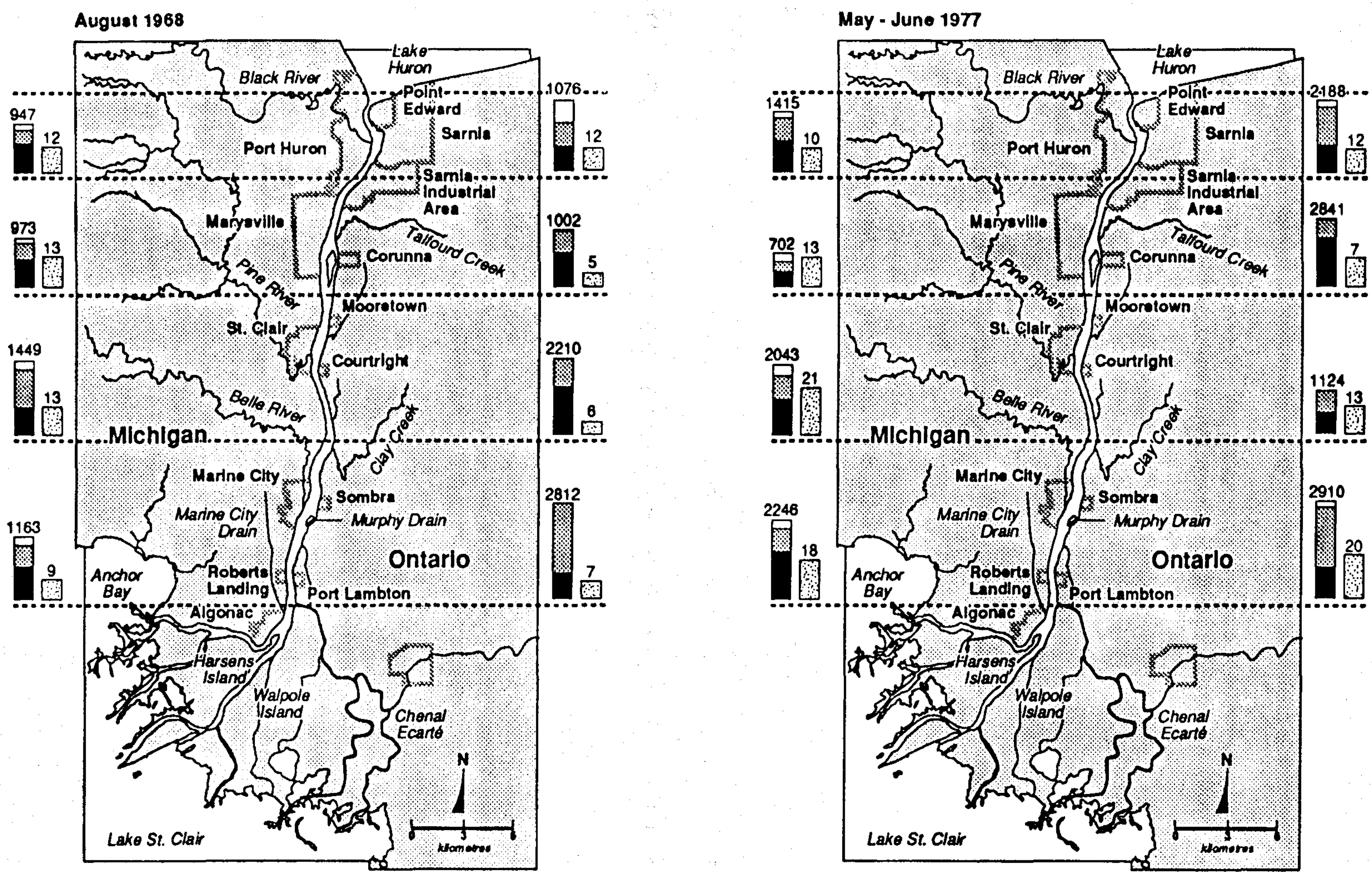


Figure 6.26

St. Clair River Remedial Action Plan

Average number of organisms per m² and average number of taxa per station in four major sections of the St. Clair River

(Thornley 1985)



1076 average number of organisms / m²

intolerant

facultative

tolerant

12 average number of taxa / station

provided for the observed increase in numbers of organisms between 1968 (average of 133 organisms/m^2) and 1977 (1,602 organisms/m^2), or for the increase in the number of observed taxa between these two periods.

In contrast with the Michigan shoreline, the impact of industry along the Ontario shoreline was evident. In 1968, there was a considerable decrease in community diversity between the first and second sections of the river as identified by Thornley (1985, Figure 6.26). The second zone corresponds to the area of concentrated industrial development in the Sarnia-Corunna areas. A 60 percent reduction in the number of taxa was seen between these two areas. Likewise, a change in community structure was noted, with all pollution-intolerant organisms being eliminated. Pollution-tolerant organisms, such as certain tubificid worms (i.e., *Tubifex spp.*), were often the only organisms seen over large areas of the river bottom. This degradation in the benthos was also apparent in the two lower zones of the river.

In 1977, the situation showed some improvement (Figure 6.26). The second zone of the river continued to show a loss of pollution-intolerant organisms as well as an overall decrease in diversity, however, downstream sections of the river showed an increase in diversity. In the lowest section of the river, the benthic community was well-balanced, with fewer pollution-tolerant organisms and a greater number of pollution-intolerant and facultative organisms.

Thornley (1985) also looked at the abundance of certain indicator species in evaluating the environmental health of the St. Clair River. For example, tubificid worms are abundant in polluted waters. Accordingly, areas where they made up greater than 80 percent of the total number of organisms were considered to have a high degree of pollution; areas where they made up 60 to 80 percent of the organisms, were considered doubtful, and areas where they contributed less than 60 percent of the overall density, were considered good.

In 1968, 20 of the 69 sampling sites (29%) in the St. Clair River had greater than 80 percent tubificid worms. Most of these sites were along the Ontario shoreline, adjacent to or downstream of the Sarnia industrial area. In 1977, only 6 of the 60 sampling sites (10%) had greater than 80 percent tubificids suggesting a reduction in the size of the impaired zone. All 6 sites were along the Ontario shoreline in the river's upper reaches.

The distribution of the environmentally-sensitive burrowing mayfly *Hexagenia limbata* was also examined. While this organism has proved to be a valuable indicator of environmental conditions in other waters including the St. Marys River and the Detroit River, its density showed little spatial or temporal variation in the St. Clair River. The abundance of this organism was low at all locations, probably more as a result of overall substrate characteristics, i.e., sand and gravel, rather than environmental quality.

The abundance of chironomids can also be used to indicate environmental quality. 'Normal' areas are defined as having at least 80 chironomids/m^2, whereas 'degraded' areas have less than 10 chironomids/m^2 (Dermott 1991). A 1986 survey of Chironomini density in the river was undertaken by Dermott (1991). An initial three day survey was made along the Ontario shore from Lake Huron downstream to the delta. Ekman grab samples were collected at intervals along the 3 to 5 m (9.8 to 16.4 ft) depth contour. A subsequent survey included resampling of areas which had abundant chironomids including at Sarnia Bay, off the mouth of Talfourd Creek, at Courtright and at the mouth of the river at Lake St. Clair. Dermott (1991) concluded that severe depopulation of the chironomid fauna occurred for a distance of about 10 km (6.2 mi) along the river from near Esso Petroleum to a point below Stag Island (Figure 6.27). Additionally, at Sarnia and Courtright, the chironomid *Procladius spp.* had a greater incidence of ligula deformities than at control sites in Lake Superior and Lake St. Clair. An increase in such mouth-part deformities has been correlated with organic contaminant concentrations in sediments (Dermott 1991).

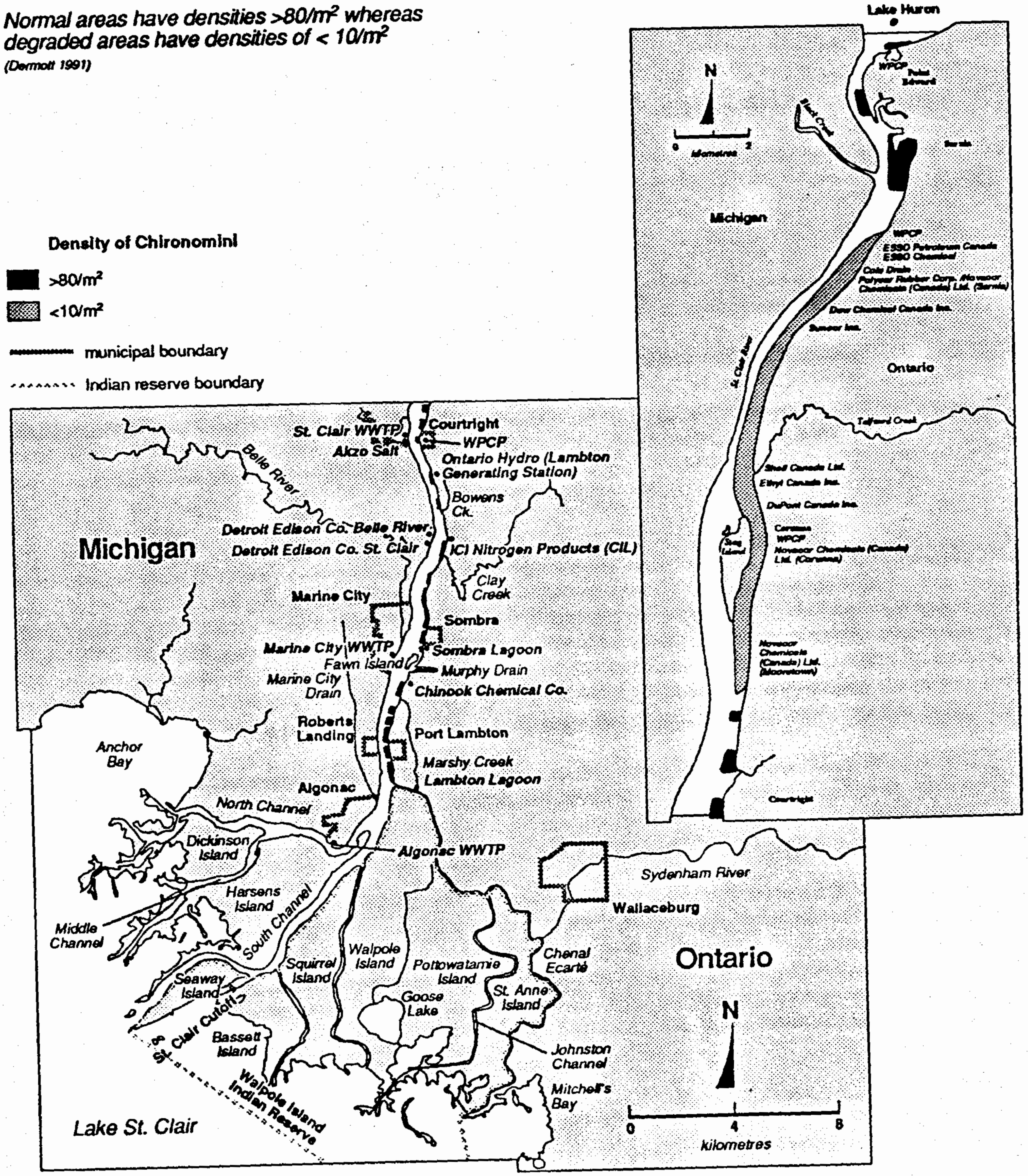
Figure 6.27

St. Clair River Remedial Action Plan

Chironomid densities along the Ontario Shoreline of the St. Clair River in 1986

Normal areas have densities >80/m² whereas degraded areas have densities of < 10/m²

(Dermott 1991)



Community Changes, 1977-1985

Studies of the benthic communities in 1985 indicated that benthic health along the U.S. shore remained good and there were further improvements in benthic health along the Canadian shore since the 1977 survey (Griffiths 1989). The results of the 1985 (May - June) studies were reported in detail by Griffiths (1989) and as part of the MISA Pilot Site Investigation (OMOE 1990a). Sampling locations included those stations sampled in the 1968 and 1977 surveys as well as additional stations placed in the lower river (Figure 6.28).

A non-hierarchical classification of benthic faunal species occurring in the river in 1985 identified 7 major assemblages or communities (OMOE 1990a). These are shown in Table 6.33. The 7 communities were classified according to environmental stress based on discriminant analysis using sediment chemistry and physical characteristics. Mean values of sediment physical and chemical characteristics associated with each community is provided in Table 6.34 (Appendix 6.2 provides the complete sediment chemistry data from the 1985 surveys).

Communities 1 through 4 reflected nonstressed environmental conditions whereas communities 5 through 7 reflected degraded environmental conditions. Community 7 was considered to represent the poorest conditions having a dominance of pollution-tolerant species such as *Limnodrilus hoffmeisteri* and *Elimia livescens* (Table 6.33). Community 7 occurred in sediments which had particularly high mean concentrations of copper, mercury, nickel, zinc, oil and grease, fibre (loss-on-ignition), total organic carbon and total phosphorus as compared to the means for other communities (Table 6.34). Mean concentrations of these parameters were also elevated at community 6 sites. Community 7 is thought to contain only organisms that have recently drifted into the area. The sediments associated with this community are thought to be too toxic to support a self-sustaining community. This would explain the presence of organisms such as *Diporeia spp.*

Figure 6.29 illustrates the distribution of environmental quality zones in the river. The environmental quality zones on this figure equate to the communities of Table 6.33 as follows: unimpaired, communities 1 to 4; impaired, community 5; degraded, community 6; and severely degraded, community 7. Toxic biological conditions occurred in a short reach of the river off Dow Chemical ('severely degraded' zone, Figure 6.29). OMOE (1990a) related these conditions to waste discharges from Dow which are known to include potentially toxic substances including aromatics, chlorinated hydrocarbons, styrene, ethylbenzene, phenols and heavy metals. Other possible sources include periodic spills from Dow and upstream sources.

The zone of good environmental quality, as reflected by a well balanced macrozoobenthos, increased in 1985 relative to 1977. The total length of the river affected by waste discharges from Ontario industries and municipalities decreased from 21 km (13 mi) in 1977 to 12 km (7.4 mi) in 1985. This 12 km zone coincides with the most heavily industrialized reach of the river.

In addition to shifts among environmental quality zones, the 1985 data also indicated that environmental quality within the impaired and degraded zones may have improved. While annelid worms (oligochaetes) and snails (gastropods) continued to dominate the fauna of the impaired zone, numbers of the pollution-tolerant worm *Tubifex tubifex*, which was abundant in 1977, decreased and the pollution-intolerant worm, *Stylodrilus herringianus* appeared in 1985. Similarly, the pollution-intolerant mayflies, *Ephemerella spp.*, *Hexagenia spp.*, *Stenonema spp.* and *Baetisca spp.*, which were absent in 1977, were present in 1985 in low numbers.

Figure 6.28

St. Clair River Remedial Action Plan

Location of benthic community sampling stations in the St. Clair River, May 1985

(Griffiths 1989)

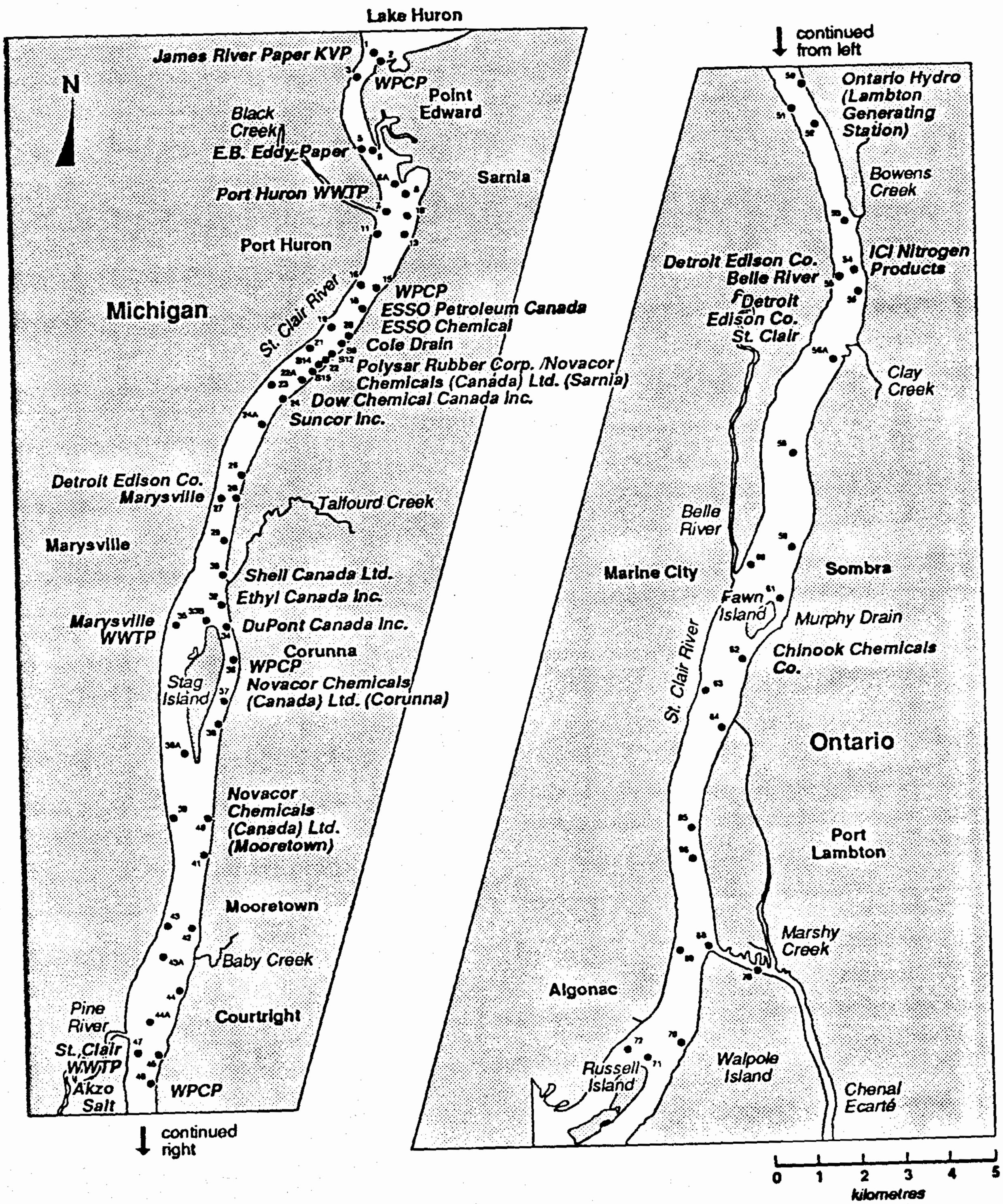


Table 6.33 Species composition (mean number/516 cm^2) of Benthic Communities 1-7 in the St. Clair River, May 1985 (OMOE 1990a).

	Benthic Community						
	1	2	3	4	5	6	7
AQUATIC CATERPILLARS							
Pyralidae			P*		P	P	
BEETLES							
Dubiraphia		P		P			
CADDISFLIES							
Cheumatopsyche		7.7	P	P		P	P
Hydropsyche		1.8	P	P	P	P	
Protoptila		1.0					
Lepidostoma				P			
Ceraclea		P					
Oecetis				P			
Neureclipsis		P	P	P			
DAMSELFLIES							
Argia						P	
Coenagrion						P	
DRAGONFLIES							
Gomphurus				P			
MAYFLIES							
Baetisca		P		P	P	P	
Caenis		1.2	4.5	1.2			
Ephemerella		P	P	P	P		
Serratella		P					
Hexagenia		P	2.8	12.3	P	P	P
Stenonema		1.2	P		P		P
STONEFLIES							
Perlesta placida		P					
TRUE FLIES							
Ceratopogonidae		P	P	2.9			
Chernovskiia	3.4						
Chironomus	P		1.8	13.3			
Cryptochironomus	2.1	P	8.8	33.0	P	P	P
Demicryptochironomus		1.1	P	2.4	P		
Dicrotendipes		P	P	P	P		
Harnischia			1.0	4.6	P	P	
Parachironomus		P	P	P	P		

Table 6.33 (cont'd)

	Benthic Community						
	1	2	3	4	5	6	7
Paracladopelma		P	P	2.6	P		
Paratanytarsus		P	P				
Paratendipes		P		P		6.0	
Phaenopsectra		P	2.6	P	P	P	
Polypedilum		P	16.2	30.7	P	P	
Pseudochironomus			P				
Rheotanytarsus				2.0			
Saetheria	3.0						
Stictochironomus			2.7	7.9			
Tanytarsus		P	3.5	15.3	P		
Tribelos		P	18.0	13.7	P	P	
Xenochironomus		P	P				
Pothastia			P	P		P	
Epicocladius				P			
Heterotrissocladius				P			
Cricotopus		P	P	P	P	1.2	P
Nanocladius		P		P		P	
Parakiefferiella	P		P				
Monodiamesa	P	P	1.0	4.0	P		
Ablabesmyia			P	3.1	P		
Djalmabatista		P	P				
Procladius		P	11.3	67.1	6.7	3.6	P
Conchapelopia		P			P	P	
Empididae	P	1.2	P	P	P	P	
Psychodidae						P	
CRUSTACEANS							
Gammarus fasciatus		1.4	6.2	4.4	1.2	P	
Diporeia spp.		P	P	P			3.6
Hyalella azteca		P	P	P	P	P	
Asellus				P		P	
CLAMS							
Pisidium	P	P	6.2	5.5	11.3	2.3	
Sphaerium		P	P	P	P		
SNAILS							
Amnicola		P	9.4	2.2	21.9	7.1	P
Probythinella lacustris			P	P			
Fossaria			P				

Table 6.33 (cont'd)

	Benthic Community						
	1	2	3	4	5	6	7
Pseudosuccinea columella			P		P	P	
Physella gyrina		1.0	2.7	P	14.4	4.0	P
Gyraulus		P	1.8	P	P	P	
Elimia livescens		6.4	2.6	P	4.2	P	2.4
Valvata piscinalis		p	3.2		13.3	5.1	
V. tricarinata		P	3.6	P	12.7	1.6	
LEECHES							
Mooreobdella microstoma					2.0	P	
Pisicolidae		P					
WORMS							
Lumbricidae		P	P	P			
Stylodrilus herringianus		P	1.2	P	1.5		
Naididae		P	5.3	4.0	4.7	6.1	
Aulodrilus americanus			P	P			
A. pleuriseta			P		P		
Ilyodrilus templetoni			1.8	1.2	4.8	9.2	
Isochaetes freyi				P			
Limnodrilus angustipenis			P	P			
L. cervix			1.5		P	45.7	
L. claparadianus		P	3.7	3.9	1.8	1.2	
L. hoffmeisteri		3.8	31.2	12.3	229.4	327.7	7.7
L. maumeensis			P	4.9			
L. udekemianus		P	1.4	3.1	2.2	15.3	P
Potamothrix moldaviensis			1.1	3.4	P	P	
P. vejdovskyi			P	P			
Quistadrilus multisetosus			2.6	8.9	20.7	15.5	P
Spirosperma ferox		P	17.3	9.6	4.4	P	
Tubifex ignotus						P	
T. tubifex						10.5	
PROBOSCIS WORMS							
Prostoma		P	P	P	P	P	P
FLATWORMS							
		4.5	4.3	2.5	3.1	P	
MEAN NUMBER OF TAXA	2.6	8.9	15.3	17.5	12.9	9.4	3.0
MEAN DENSITY OF ORGANISMS	9.9	47.3	216.6	331.9	489.9	602.1	17.1

* P denotes a mean density of less than 1 individual per sample

Table 6.34 Mean values of physical and chemical sediment characteristics associated with benthic communities 1 through 7 from the St. Clair River, May 1985. All values are in $\mu g/g$ unless otherwise noted (Griffiths 1989).

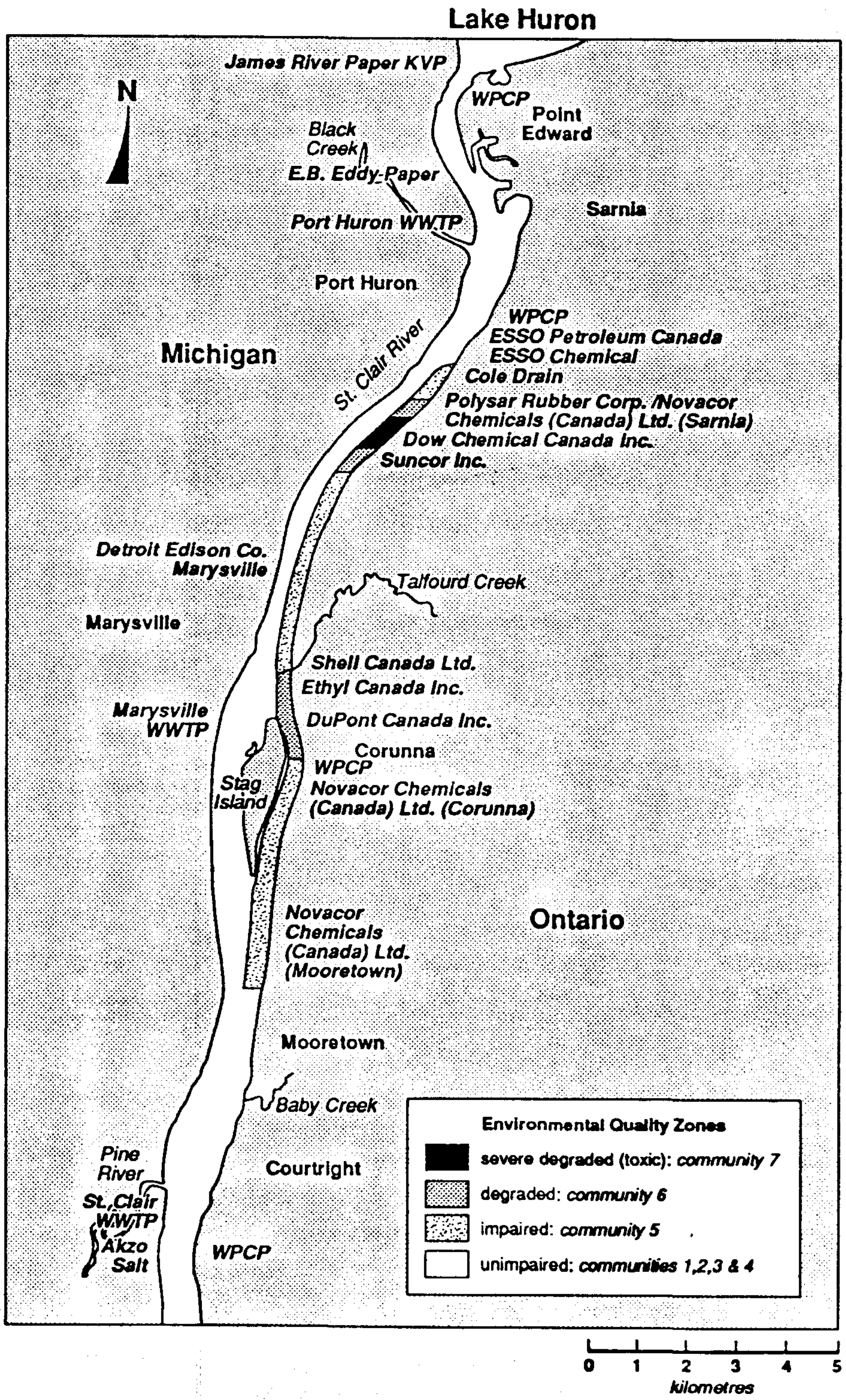
Parameters	Benthic Communities						
	1	2	3	4	5	6	7
Iron	3870	16340	8180	12630	8310	8330	10110
Manganese	90	210	160	250	190	170	200
Arsenic	1.83	7.46	4.15	6.56	5.70	5.03	5.17
Cobalt	2.19	6.49	4.80	6.19	5.35	5.43	6.63
Chromium	6.37	18.88	13.59	17.53	16.24	8.82	20.90
Copper	4.54	43.08	16.92	29.80	19.40	29.90	74.44
Mercury	0.02	0.19	0.43	0.11	2.11	4.78	15.03
Nickel	2.53	13.67	8.25	12.14	7.94	8.81	21.79
Lead	2.22	34.92	16.52	17.47	22.28	89.66	21.89
Zinc	11.32	45.15	34.94	54.75	65.65	67.64	96.73
Oil and Grease	70	520	480	880	630	2540	2030
Loss-on-Ignition	2910	12780	8920	17620	13300	25490	18120
Total Organic Carbon	5000	8280	7390	13620	11060	19520	13410
Total Phosphorus	100	220	210	290	230	260	270
Total Kjeldahl Nitrogen	130	360	350	710	450	690	370
Particle Size -% gravel	0.60	67.00	0.70	0.00	25.30	7.40	45.20
-% sand	98.40	32.00	79.20	51.80	35.80	52.00	46.90
-% silt and clay	1.00	1.00	20.10	48.20	38.90	40.60	7.90

Figure 6.29

St. Clair River Remedial Action Plan

Location of zones of benthic community impairment in the St. Clair River during the spring of 1985

(Griffiths et al. 1991)



6.3.3.2.4 Heavy Metals

There are very few studies which have examined the concentration of metals in benthic invertebrates in the St. Clair River. Most of the studies on contaminant levels in benthic tissue undertaken to date have focused on toxic organic contaminants. The following discussion is based primarily on sampling undertaken in 1983 by Persaud et al. (1987) and Pugsley et al. (1988) and in 1985-1986 by Chau et al. (1988).

In 1983, the OMOE carried out the first phase of its In-Place Pollutants Program (Persaud et al. 1987), which was designed to obtain information on the physical and chemical characteristics of surficial sediments, and the levels of contaminants in representative species of benthic invertebrates in the river. The overall objective was to investigate the impact of sediment contamination on overlying water quality and aquatic biota. Of the eight stations sampled during the 1983 survey, sufficient quantity of benthic tissue for analysis was obtained only from one station which was located between 14 and 15 km (8.7 to 9.3 mi) downstream from Lake Huron at the northwest end of Stag Island. It is within the area influenced by the central, less contaminated plume of the river.

While a number of stations in the river had elevated concentrations of mercury and oil and grease in the sediments, concentrations of these parameters as well as copper, zinc, lead, iron and cadmium at this site were less than the OMOE guidelines for the open water disposal of dredged material. Oligochaetes were the predominant group of organisms found and were comprised mainly of *Limnodrilus hoffmeisteri* and the pollution-tolerant *Tubifex tubifex*. The reason for the presence of this latter organism within a relatively 'clean' site is not known. However, this area was also identified by Hamilton (1987) as having the lowest biologic index (Integrated Biologic Index) of eleven areas which were surveyed by electrofishing in the river during 1986.

Most chemical contaminants were associated with the fine-grained (<63 micron) sediment fraction. Strong correlations were also noted between the levels of metals in bulk sediment and the organic content of the sediment, suggesting that the distribution pattern of the parameters was governed mainly by their association with organic material, especially the solvent extractables (oil and grease). The <63 micron fraction consists primarily of silt and clay components of sediment. This is the size range normally ingested by benthic invertebrates.

The analytical process consisted of a sequential chemical leaching process which allowed the determination of the geochemical partitioning of the metals (Persaud et al. 1987). Based on increasing strength of the extraction fluid, the geochemical phases consist of:

IW	-	pore water;
F1	-	cation exchangeable/weakly absorbed metal ions;
F2	-	specifically absorbed and easily reducible metals;
F3	-	organic/sulphide-bound metals;
F4	-	moderately reducible (Fe/Mn oxides) metals; and
F5	-	residual metals

The extractions from phases IW through F4 (inclusive) identify the portion of the metals which are available for uptake by biota whereas F5 represents unavailable forms. Results from the sediment extractions at this site indicate that over 75 percent of the copper, cadmium, lead, manganese, and zinc was in available forms. In contrast, less than 35 percent of iron was available for uptake.

Concentrations of copper, lead, cadmium, iron, and manganese in the tissue of oligochaetes were low compared with the available sediment values. Consequently the respective bioconcentration factors (BCF) for these metals were all less than one (Table 6.35). In contrast, the level of zinc in benthic tissue was higher at this station than in sediment, with a resultant BCF greater than one (1.9). It is not known if these bioconcentration factors are representative.

Table 6.35 Concentrations of metals in sediment (µg/g dry weight) and in benthic tissue (oligochaetes, µg/g dry weight, gut-corrected) at the north end of Stag Island, station 66 (Persaud *et al.* 1987).

	Sediment	Benthic Tissue	BCF
Copper	22.3	9.6	0.4
Zinc	43.3	82.2	1.9
Lead	20.2	2.7	0.1
Cadmium	0.8	0.3	0.4
Iron	5,135.9	553.3	0.1
Manganese	210.8	11.9	0.1
Mercury	—	—	—
Arsenic	—	—	—

*BCF - bioconcentration factor

The results of this study are inconclusive given the limited data base. The relationship between metal concentrations in benthic organisms and those in the sediment that organisms feed on is complex (Edsall et al. 1988b). The determination of metal availability via the sequential extraction process and comparison between sediment and benthic tissue concentrations reveal that the actual amounts of metals taken up by benthos is not necessarily equivalent to the amounts potentially available. Other factors such as physio-chemical processes and the amount of organic matter in sediments may also play a role (Edsall et al. 1988b).

Pugsley et al. (1988) analyzed lead and cadmium in the unionid mussel *Lampsilis radiata siliquoidea* and associated sediments collected from stations in the Canadian waters of the St. Clair River. A total of 24 stations were located along the entire length of the river including stations at the head (in southern Lake Huron) and mouth (South Channel in the delta) of the river.

Sufficient samples of unionid mussels for analysis were found only at stations located in southern Lake Huron, at the head of the river, downstream of Sarnia at Stag Island, and in South Channel. The mean and ranges for all St. Clair River stations are reproduced in Table 6.36. Cadmium in mussels averaged 8.2 µg/g (5.2 to 14.7 µg/g dry weight) and lead averaged 9.4 µg/g (5.6 to 16 µg/g dry weight) in the St. Clair River. It is not known if these concentrations are sufficient to impair the benthic community. The mean of tissue samples from the head of the river was 12.0 µg/g for lead and 14.7 µg/g for cadmium. The highest mean lead concentrations were found in the South Channel (16.0 µg/g) and central Lake St. Clair (40.0 µg/g) whereas the highest mean cadmium concentration occurred in central Lake St. Clair (19.0 µg/g).

No significant correlation existed between the levels of lead and cadmium in individual mussels, nor between the level of either lead or cadmium in a mussel and sediment at the same site (Pugsley et al. 1988). The authors concluded that due to this lack of correlation the mussels within the St. Clair River obtain most of their metal contaminant load directly from the water rather than from sediment. In contrast, the organic content of the sediments in Lake St. Clair were more important with regard to body burdens in mussels than differential concentrations of heavy metals in water masses passing over them.

Table 6.36 Concentrations of lead and cadmium in unionid mussels (*Lampsilis radiata siliquoidea*) and sediment collected from the St. Clair River during 1983 (from Pugsley et al. 1988). Units are in µg/g dry weight.

	n	Mean	Maximum	Minimum
Mussel Lead	6	9.4	16.0	5.6
Sediment Lead	24	34.8	337.0	4.0
Mussel Cadmium	6	8.2	14.7	5.2
Sediment Cadmium	24	0.09	0.04	0.19

The highest mussel lead levels of the entire Huron - Detroit River corridor were found in the sample from South Channel whereas the highest mussel cadmium levels were found in the centre of Lake St. Clair. Pugsley et al. (1988) concluded that the variability in mussel body burdens reflect differential exposure to contaminants. The pattern of contamination, with highest concentrations occurring at stations in the South Channel (lead) and in Lake St. Clair (cadmium) suggest that industrial discharges into the St.Clair River from Canadian sources are the primary source of cadmium and lead pollution to the system (Pugsley et al. 1988).

During 1985 and 1986, experiments were conducted by Environment Canada (Chau et al. 1988) in the vicinity of Ethyl Corporation to investigate the bioconcentration of alkyllead compounds by caged mussels (*Elliptio complanata*) and other biota. The highest concentration of alkyllead (0.156 µg/g) in whole mussel tissues was consistently found at a location 0.7 km (0.4 mi) downstream from the effluent outfall (approximately 14 km/8.7 mi downstream from Lake Huron). Contamination decreased with increasing distance from the discharge pipe, however, it was still evident in mussels as far as 2.8 km (1.7 mi) downstream from the outfall. Triethyllead was the predominant alkyllead compound in the mussels (maximum 0.098 µg/g), while concentrations of diethyllead were generally very low or at trace levels. Within mussel tissues, the highest alkyllead concentrations were found in viscera, followed by the gills and mantle tissues (Chau et al. 1988). These concentrations were much lower than those found by Pugsley et al. (1988) including stations both upstream and downstream of Ethyl Corporation.

6.3.3.2.5 Organochlorines

Studies of sediment and benthic faunal organic contaminant concentrations in the St. Clair River have been carried out primarily by the Ontario Ministry of the Environment and the University of Windsor. OMOE studies include contaminant uptake in introduced mussels (*Elliptio complanata*) during 1982 (Kauss and Hamdy 1985), 1984 (Edsall et al. 1988b) and 1986 (OMOE 1990a); as well as in native mayfly larvae (*Hexagenia spp.*) collected in 1986 under the MISA Pilot Site Investigation (OMOE 1990a). University of Windsor studies included native unionid mussels (*Lampsilis radiata siliquoidea*) collected in 1983 (Pugsley et al. 1985); native mayflies and caddisflies (Ephemeroptera and Trichoptera taxa) collected in 1986 (Ciborowski and Corkum 1988); and introduced mussels (*Elliptio complanata*) placed in the river during 1986 and 1987 (Muncaster et al. 1989).

Mussel Studies

Caged mussels were placed in 13 locations in the river from upstream of Sarnia to the South Channel in the delta for a 3 week period in 1982 (Kauss and Hamdy 1985). All but 4 of the stations were located on the Canadian shore.

Hexachlorobenzene, octachlorostyrene, pentachlorobenzene, hexachlorobutadiene, 2,3,6-trichlorotoluene and alpha-BHC were the most frequently identified contaminants detected in mussel tissue. Mussels from the Sarnia to Corunna area were found to contain significantly ($p \leq 0.05$) higher levels of hexachlorobenzene, octachlorostyrene, pentachlorobenzene and hexachlorobutadiene than did mussels from other locations in the river. Low levels of PCBs were restricted to mussels from the Sarnia area but were nondetectable at all downstream stations. Concentrations of all parameters were either nondetectable or near the detection limit at the four Michigan stations.

A similar study was carried out in 1984, looking at the uptake of chlorinated organics by mussels held at 21 different locations (Edsall et al. 1988b). While most of the contaminants analyzed were below detection limits at the four Michigan sites, PCBs were found at low concentrations (trace to 0.043 $\mu g/g$) at three of the sites. The DDT metabolite p,p'-DDE was also detected on the Michigan side.

Contamination patterns in both water and mussels suggest that inputs of hexachloroethane, octachlorostyrene, hexachlorobutadiene, 2,4,5-trichlorotoluene, pentachlorobenzene, hexachlorobenzene, 1,2,4-trichlorobenzene, 1,2,3,5 and 1,2,4,5-tetrachlorobenzene, and PCBs occurred along a 1.8 km (1.1 mi) section of the Sarnia industrial waterfront from the Cole Drain to immediately downstream of Dow Chemical. Figures 6.30 to 6.34 illustrate the results for octachlorostyrene, total PCBs, hexachlorobutadiene, pentachlorobenzene and hexachlorobenzene, respectively. Downstream from this area, uptake of these contaminants decreased rapidly. Inputs to the river between Talfourd Creek and Polysar in Corunna contributed 1,3,5-trichlorobenzene, pentachlorobenzene and 1,2,3,5-tetrachlorobenzene.

Several volatile organic compounds including benzene, chloroform, ethylbenzene and xylene were also found in caged mussels within the heavily impacted area.

The downstream extent of the impact of Sarnia sources of octachlorostyrene and PCBs was evident from the fact that detectable levels of these two parameters were found in mussels exposed at Port Lambton, some 35 km (21.7 mi) distant (Figures 6.30 and 6.31). This was also the case for hexachlorobutadiene (Figure 6.32), pentachlorobenzene (Figure 6.33) and hexachlorobenzene (Figure 6.34), although it is not obvious owing to the ordinate axis scale used in the figures.

Several of the above-noted organochlorines were accumulated to a significant degree by caged mussels. Table 6.37 lists the calculated bioconcentration factors (BCF) for mussels exposed at two locations along the Sarnia nearshore. No BCF could be calculated for PCB because it was not detected in any water samples at the routine method detection limit of 0.02 $\mu g/L$. There is fairly good agreement between the BCFs calculated for stations situated 100 m (328 ft) and 1,000 m (3,280 ft) downstream of Dow's 1st Street Sewer complex for all parameters except hexachloroethane (Table 6.37). The accumulation of these organochlorine contaminants by caged mussels indicates the potential for their bioaccumulation by locally resident filter feeders such as native mussels, clams and chironomids (Edsall et al. 1988b).

Figure 6.30

St. Clair River Remedial Action Plan

Octachlorostyrene in St. Clair River water and caged mussels along the Ontario shore in 1984

Detection limit is 0.001 µg/L for water; 0.001 µg/g for biota

(Edsall et al. 1988b)

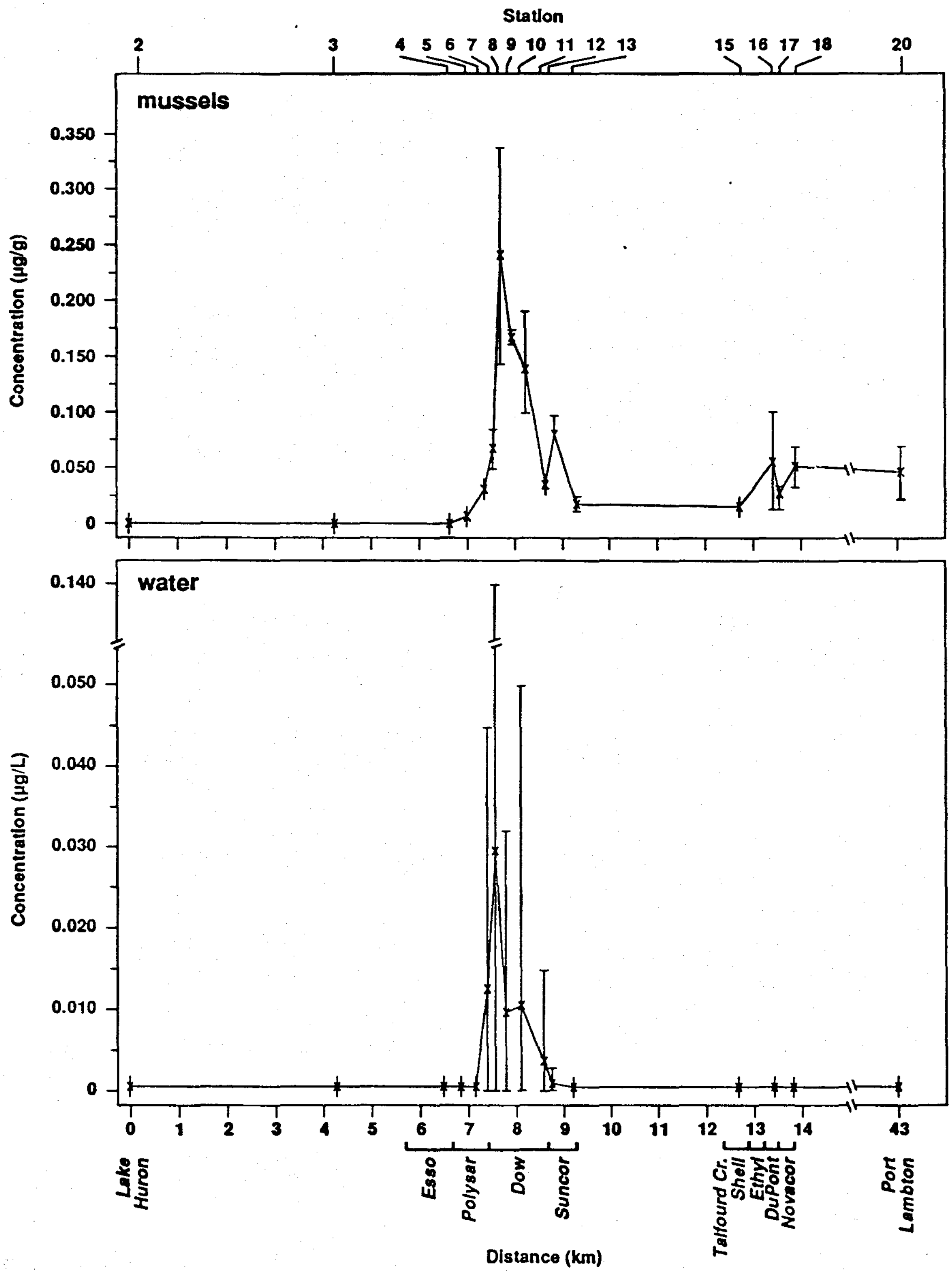


Figure 6.31

St. Clair River Remedial Action Plan

Total PCBs in St. Clair River caged mussels along the Ontario shore in 1984

Detection limit is 0.02 µg/g for biota

(Edsall et al. 1988b)

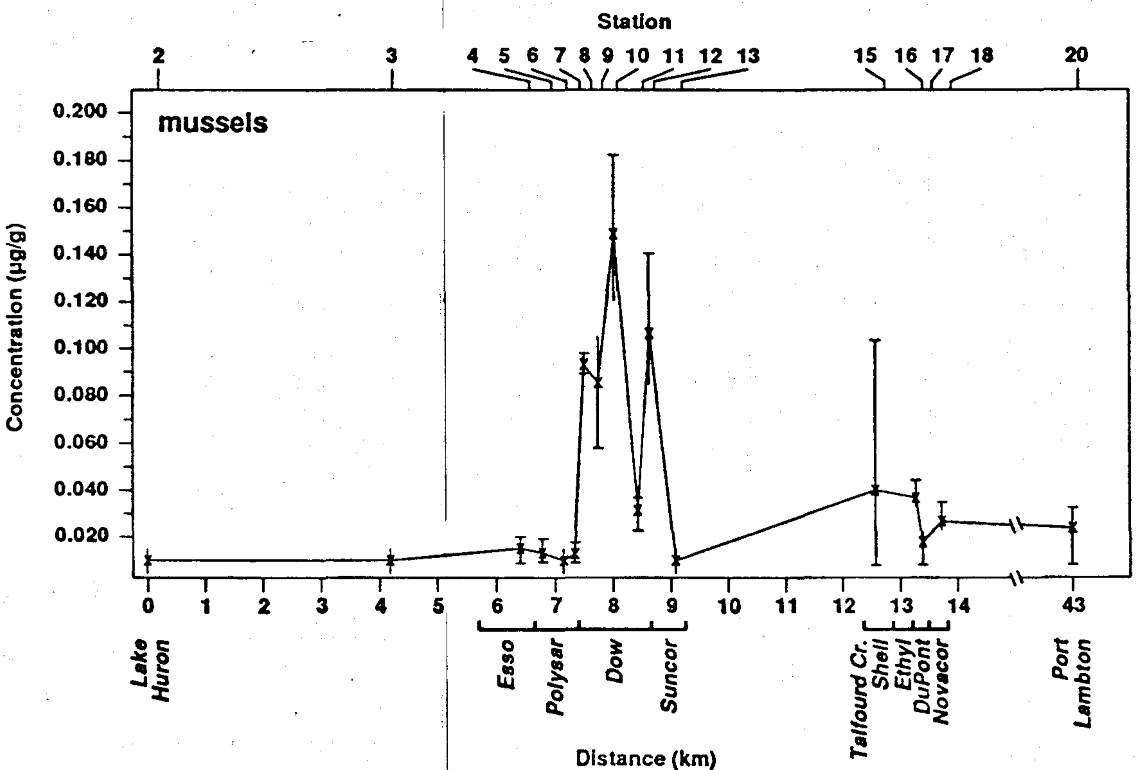


Figure 6.32

St. Clair River Remedial Action Plan

Hexachlorobutadiene in St. Clair River water and caged mussels along the Ontario shore in 1984

Detection limit is 0.001 µg/L for water; 0.001 µg/g for biota

(Edsall et al. 1988b)

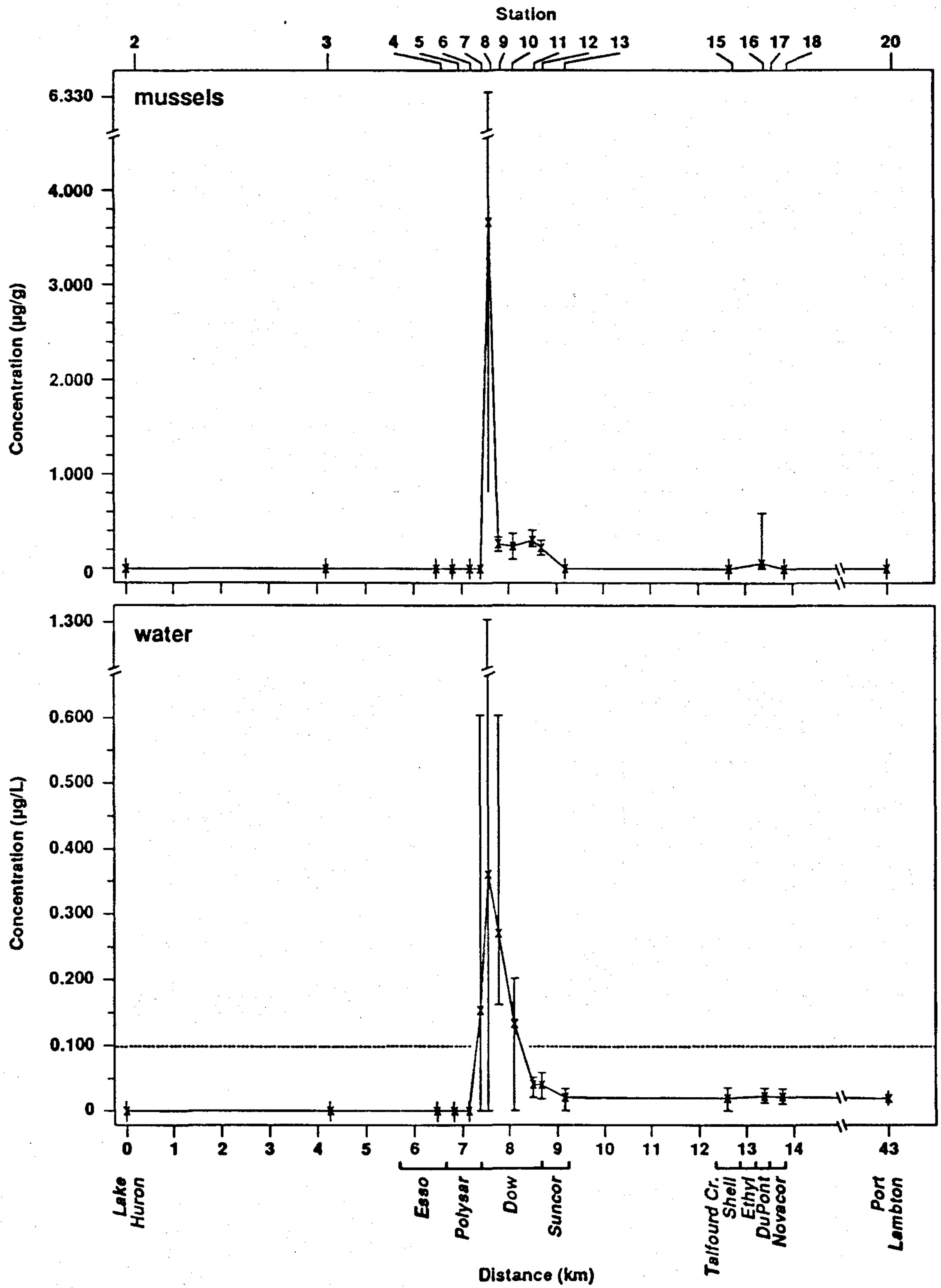


Figure 6.33

St. Clair River Remedial Action Plan

Pentachlorobenzene in St. Clair River water and caged mussels along the Ontario shore in 1984

Detection limit is 0.001 µg/L for water; 0.001 µg/g for biota

(Edsall et al. 1988b)

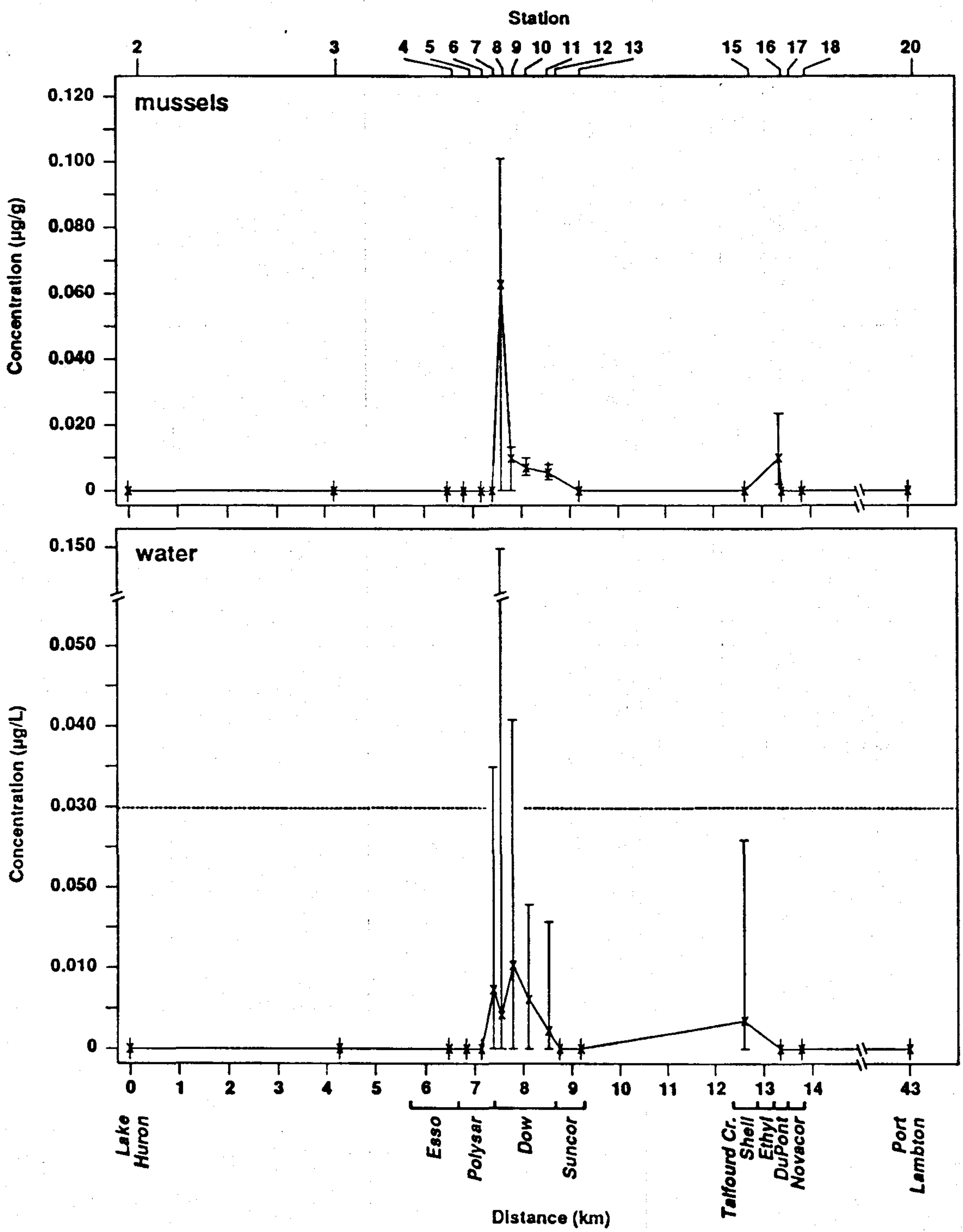


Figure 6.34

St. Clair River Remedial Action Plan

Hexachlorobenzene in St. Clair River water and caged mussels along the Ontario shore in 1984

Detection limit is 0.001 µg/L for water; 0.001 µg/g for biota

(Edsall et al. 1988b)

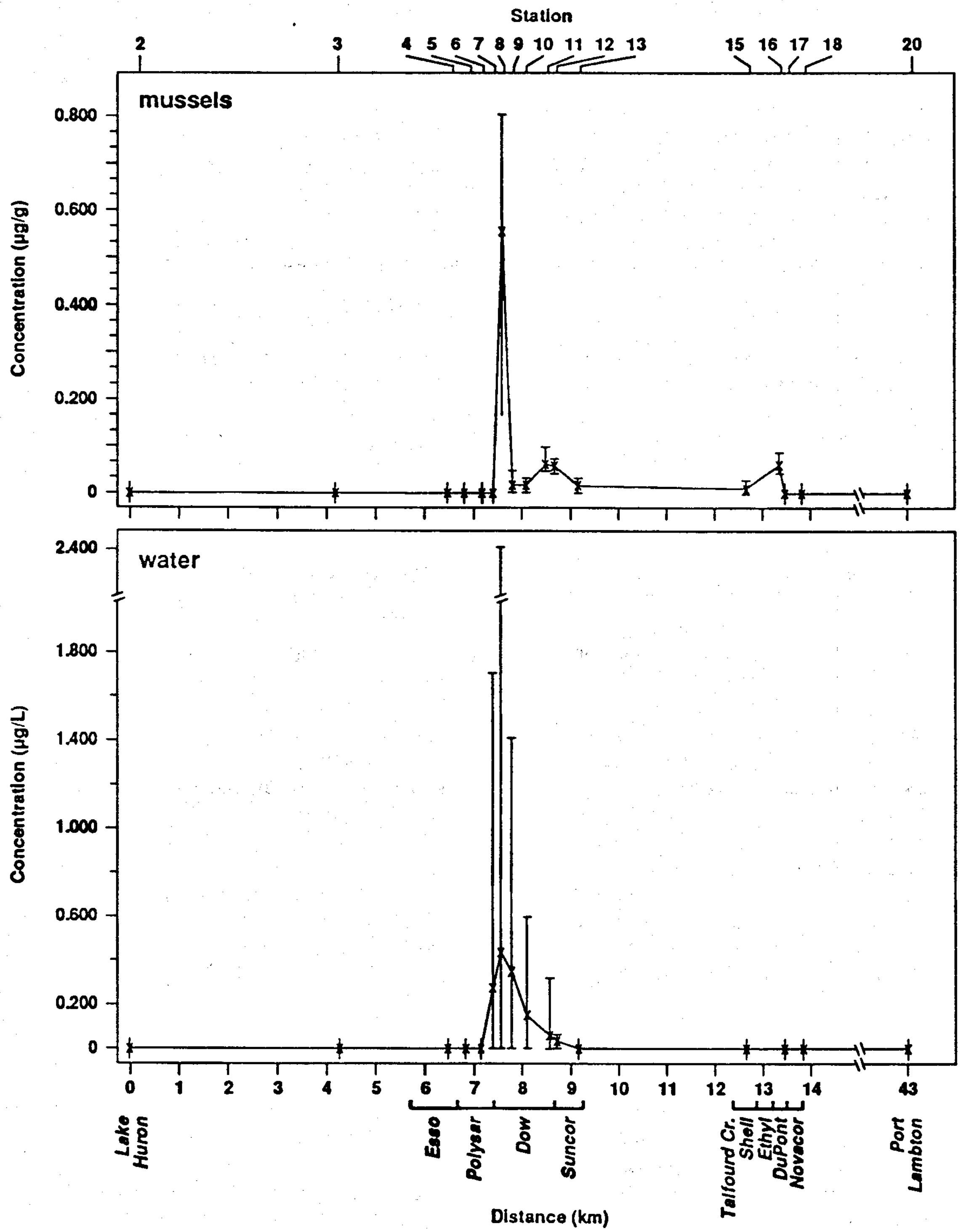


Table 6.37 Bioconcentration factors (BCF) of selected organochlorine contaminants in water and caged mussels (*Elliptio complanata*) exposed for 18 weeks 100 m/1000 m (328 ft/3280 ft) downstream of Dow's 1st Street outfall and in St. Clair River fish (Edsall et al. 1988b).

Compound			Bioconcentration Factor	
	Mussels (μg/g)	Water (μg/L)	Mussels	Fish
Hexachloroethane	0.176/0.002	0.182/0.037	967	138-708
Hexachlorobutadiene	3.59/0.336	0.381/0.038	9,422/8,842	6,918
2,4,5-Trichlorotoluene	0.156/0.007	0.145/0.005	1,076/1,400	-
Pentachlorobenzene	0.063/0.006	0.028/0.003	2,250/2,000	3,388-12,882
Hexachlorobenzene	0.551/0.069	0.443/0.057	1,244/1,211	7,762-23,442
Octachlorostyrene	0.240/0.036	0.027/0.004	8,889/9,000	33,113
PCBs	0.096/0.033	Not detected		100,000

At ten of the 1984 caging sites, mussels were also analyzed for PAHs (Edsall et al. 1988b). Naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene-benzo(a)anthracene, benzo(b)fluoranthene-benzo(k)fluoranthene, benzo(a)pyrene, benzo(e)pyrene, perylene, benzothiophene, dibenzothiophene and acridine were all detected at concentrations above those detected in mussels held at the head of the river. Following 18 weeks of exposure, the highest concentrations of total PAHs were found in mussels held just downstream from Esso Petroleum (0.906 μg/g) and Shell Petroleum Refineries (0.418 μg/g). These concentrations indicate the presence of nearby sources of biologically available material. Lesser sources of specific PAH isomers were also noted in the vicinity of the Suncor Refinery, upstream of the river in Lake Huron, upstream of Marysville, Michigan and upstream of Port Lambton.

The 1983 study conducted by the Great Lakes Institute on native unionid mussels (Pugsley et al. 1985) obtained sufficient mussel samples at only 6 of 24 stations in the river and Lake Huron. PCB concentrations in mussels taken from downstream of the Sarnia industrial complex were nondetectable. The highest concentration for Aroclor 1254 occurred along the south shore of Lake Huron (0.105 μg/g). This result suggests that at least part of the total PCB burden found in introduced mussels offshore of the Sarnia area industrial complex in 1984 (Edsall et al. 1988b) may originate from sources upstream of the Area of Concern.

Octachlorostyrene concentrations in mussels collected in 1983 by Pugsley et al. (1985) were less than 0.008 μg/g at all stations, including east of Stag Island (0.004 μg/g) except in the South Channel where the highest concentration within the entire Huron - Detroit River corridor was found (0.193 μg/g). This high level in the South Channel, along with the pattern of sediment contamination within the river (24 stations), was interpreted as resulting from upstream industrial sources.

The 1986 caged mussel studies undertaken as part of the MISA Pilot Site Investigation were intended to complement and update the earlier studies (1982) and identify and quantify those compounds which are bioavailable and may tend to concentrate (OMOE 1990a).

Mussels were placed in the river at 11 stations (Figure 6.10). Head and mouth stations had mussels deployed at mid-depth only whereas for the remainder of stations they were placed at mid-depth and on the bottom. Equal numbers of mussels were retrieved 31 days and 134 days after deployment. Analyses of mussel tissue included 26 volatile organic compounds and 14 chlorinated organics. Factors associated with high current velocity, accidents related to sport and commercial fishing and direct tampering were identified to explain low mussel recoveries. Seven of 11 stations were recovered following the 31 day exposure and only 3 of 10 were recovered after 134 days.

The results for selected contaminants are shown in Table 6.38. Uptake levels were highest downstream of the Sarnia industrial complex, particularly in the vicinity of Dow Chemical and the southern boundary of Suncor. Hexachlorobenzene concentrations were highest in samples collected after 4 weeks at Station 206 located offshore from Dow (Figure 6.10). Although the second retrieval could not be obtained, Muncaster et al. (1989) suggest that peak concentrations are obtained after only 3 weeks. The hexachlorobenzene data for the two exposure times at Station 18, however, suggests that it may be between 4 and 19 weeks. A stepwise reduction in hexachlorobenzene concentrations were observed with increasing distance downstream reflecting a gradual improvement in conditions (OMOE 1990a). The pattern of hexachlorobutadiene concentration was similar to hexachlorobenzene except that a higher concentration was found at Station 211 (downstream of the Dow 3rd Street Sewer) relative to Station 206 (Table 6.38). The highest concentration of hexachlorobutadiene (0.151 $\mu g/g$) occurred downstream from Suncor after 4 weeks exposure.

In addition to the results shown in Table 6.38, several volatiles including benzene, chloroform, ethylbenzene and xylene were repeatedly measured in mussel tissue. The concentration of xylene was twice as high at Station 132 (offshore Esso Petroleum) than the next highest concentrations (Station 206). Esso produces large quantities of xylene. High concentrations of ethylbenzene were found at Station 206 located offshore of Dow and downstream of Polysar (Figure 6.10).

The 1986/87 studies by the University of Windsor involved introduced mussels of the same species (*Elliptio complanata*) used in the three earlier studies by the Ontario Ministry of the Environment. Mussels were introduced to four locations in the St. Clair Delta and exposed for periods ranging from one to 12 weeks in each year (Muncaster et al. 1989). Analyses were undertaken for pentachlorobenzene, hexachlorobenzene and octachlorostyrene.

Body burdens of hexachlorobenzene and pentachlorobenzene were less than those reported for 1982 (Kauss and Hamdy 1985) in the same species at a station located immediately north of the 1986/87 Walpole station. Mussels exposed for comparable time periods accumulated mean pentachlorobenzene and hexachlorobenzene levels averaging 0.0004 and 0.0022 $\mu g/g$, respectively, in the later study, compared to mean values of 0.001 and 0.004 $\mu g/g$, respectively, in 1982. Similarly, the mean octachlorostyrene level of 0.029 $\mu g/g$ observed in 1982 was much greater than the 0.0052 and 0.0034 $\mu g/g$ averages noted in 1986 and 1987. In addition, body burdens of hexachlorobenzene and octachlorostyrene declined 49 and 41 percent, respectively, in mussels deployed in 1987 relative to 1986 (Muncaster et al. 1989).

Muncaster et al. (1989) conclude that the trend toward lower body burdens in mussels downstream of industries in the St. Clair River substantiates reported decreases in contaminant discharges by industry.

<u>Aquatic Insects</u>

Both studies describing contaminants in aquatic insects were based on samples collected in 1986. Using principal component analysis, Ciborowski and Corkum (1988) found significant concentrations (explaining 84 percent of the variation among the 40 samples) of pentachlorobenzene, hexachlorobenzene, octachlorostyrene and 16 PCBs in extracts from adult mayflies and caddisflies. Samples were collected from 4 St. Clair River and 4 Detroit River stations. St. Clair River stations were located at Port Lambton, Sombra, Corunna and Sarnia. Concentrations of PCBs were found to be significantly greater in caddisflies emerging from Detroit River sites whereas the other 3 compounds occurred at highest concentrations in caddisflies emerging from the St. Clair River. These results are consistent with the mussels studies with regard to sources of pentachlorobenzene, hexachlorobenzene and octachlorostyrene along the St. Clair River.

Table 6.38 Mean mussel tissue concentrations of hexachlorobenzene (HCB), hexachlorobutadiene (HCBD), hexachloroethane (HCE), octachlorostyrene (OCS), tetrachloroethylene (TECE), benzene and ethylbenzene at St. Clair River stations (OMOE 1990a). Values are in $\mu g/g$ and n=3, unless otherwise indicated (in brackets). Sample locations are shown in Figure 6.10.

Station	HCB	HCBD	HCE	OCS	Benzene	TECE	Ethyl-benzene
132 mid. 132 bot.	ND/- ND/-	ND/- ND/-	ND/- ND/-	- -	-/- 0.0096(2)/-	-/- ND(2)/-	-/- 0.128(2)/-
206 mid. 206 bot.	0.035/- 0.033/-	0.056/- 0.049/-	ND/- ND/-	- -	-/- 0.0128(2)/-	-/- 0.0055(2)/-	-/- 0.033(2)/-
211 mid. 211 bot.	0.01/- 0.019/-	0.02/- 0.069/-	ND/- ND/-	- -	-/- -/-	-/- -/-	-/- -/-
216 mid. 216 bot.	0.009/- 0.021/-	0.015/- 0.021/-	ND/- ND/-	- -	-/- 0.0112(2)/-	-/- 0.0166(2)/-	-/- 0.0335(2)
18 mid. 18 bot.	-/0.014 0.019/0.033	-/0.003 0.151/0	-/ND ND/ND	-/0.032 -/0.033	-/- 0.0042(2)/0.011(3)	-/- 0.006(2)/0.0042(3)	-/- 0.01(2)/0(3)
218 bot.	-/0.011*	-/0.004*	-/ND*	-/0.022*	-/0.013(2)*	-/ND(2)*	-/ND(2)*
214C mid. 214C bot.	0.004/- 0.003/0.01(6)	0.004/- 0.003/0(6)	- -	- -	-/- -/0.01(1)	-/- -/ND(1)	-/- -/ND(1)
214V mid. 214V bot.	ND/- ND/-	ND/- ND/-	- -	- -	-/- -/-	-/- -/-	-/- -/-
Control (Balsam Lake)	ND(5)	ND(5)	ND(5)	ND(5)	-	-	-

Exposure periods: 4 weeks/19 weeks
* 15 weeks
- Not measured
ND Not Detected

The MISA Pilot Site Investigation (OMOE 1990a) included benthic sampling coincident with water and sediment sampling at 9 stations. These were located as shown in Figure 6.35. Although several types of benthos were sampled and analyzed, the mayfly larvae *Hexagenia spp.* was the most consistently collected. Concentrations of hexachloroethane were at or below the detection level in all media at all locations. Detectable levels of hexachlorobutadiene were found in *Hexagenia spp.* but no spatial trend was apparent and there was no relationship with concentrations in sediment.

Concentrations of hexachlorobenzene and octachlorostyrene in *Hexagenia spp.* were positively correlated to levels in sediment. Based on the pattern of sediment concentration (all sites did not have sufficient quantity of benthic sample), hexachlorobenzene increased from 0.002 μg/g (Table 6.39) upstream of the Sarnia industrial complex to 0.108 μg/g downstream of Polysar and 0.35 μg/g downstream of Dow. Concentrations declined with distance downriver then rose to peak again at station 34 (Port Lambton). Octachlorostyrene sediment concentrations were <0.001 μg/g upstream of the Sarnia complex (Table 6.39) and were at a maximum at station 218 downstream of Dow. Elevated concentrations were also observed at three stations in the lower river (Table 6.39). These results are consistent with the mussel data of Pugsley et al. (1985), OMOE (1990a), Kauss and Hamdy (1985) and Edsall et al. (1988b) indicating that sources on the Ontario side of the St. Clair River downstream of Sarnia are responsible for hexachlorobenzene and octachlorostyrene contamination within the St. Clair River ecosystem.

Table 6.39 Concentrations of hexachlorobenzene (HCB) and octachlorostyrene (OCS) in bottom water (μg/L), bulk sediment (μg/g dry weight), *Hexagenia spp.* (μg/g wet weight), and Sculpin (μg/g wet weight) at St. Clair River stations in 1986 (OMOE 1990a).

	Water		Sediment		*Hexagenia spp.*		Sculpin	
Station	OCS	HCB	OCS	HCB	OCS	HCB	OCS	HCB
control	-	-	-	-	-	-	0.006	0.003
219	<0.001	<0.001	<0.001	0.002	-	-	-	-
110	<0.001	<0.001	<0.001	0.003	-	-	-	-
203	<0.001	<0.001	<0.001	0.108	-	-	-	-
218	<0.001	<0.001	0.054	0.35	-	-	-	-
38A	<0.001	<0.001	<0.001	0.002	0.003	0.012	0.002	0.003
64	<0.001	<0.001	<0.001	0.01	<0.002	0.006	0.008	0.005
68	<0.001	<0.001	0.04	0.064	0.02	0.045	0.04	0.018
34	<0.001	0.002T	0.059	0.2	0.018	0.126	-	-
115	<0.001	<0.001	0.008	0.031	0.008	0.02	-	-

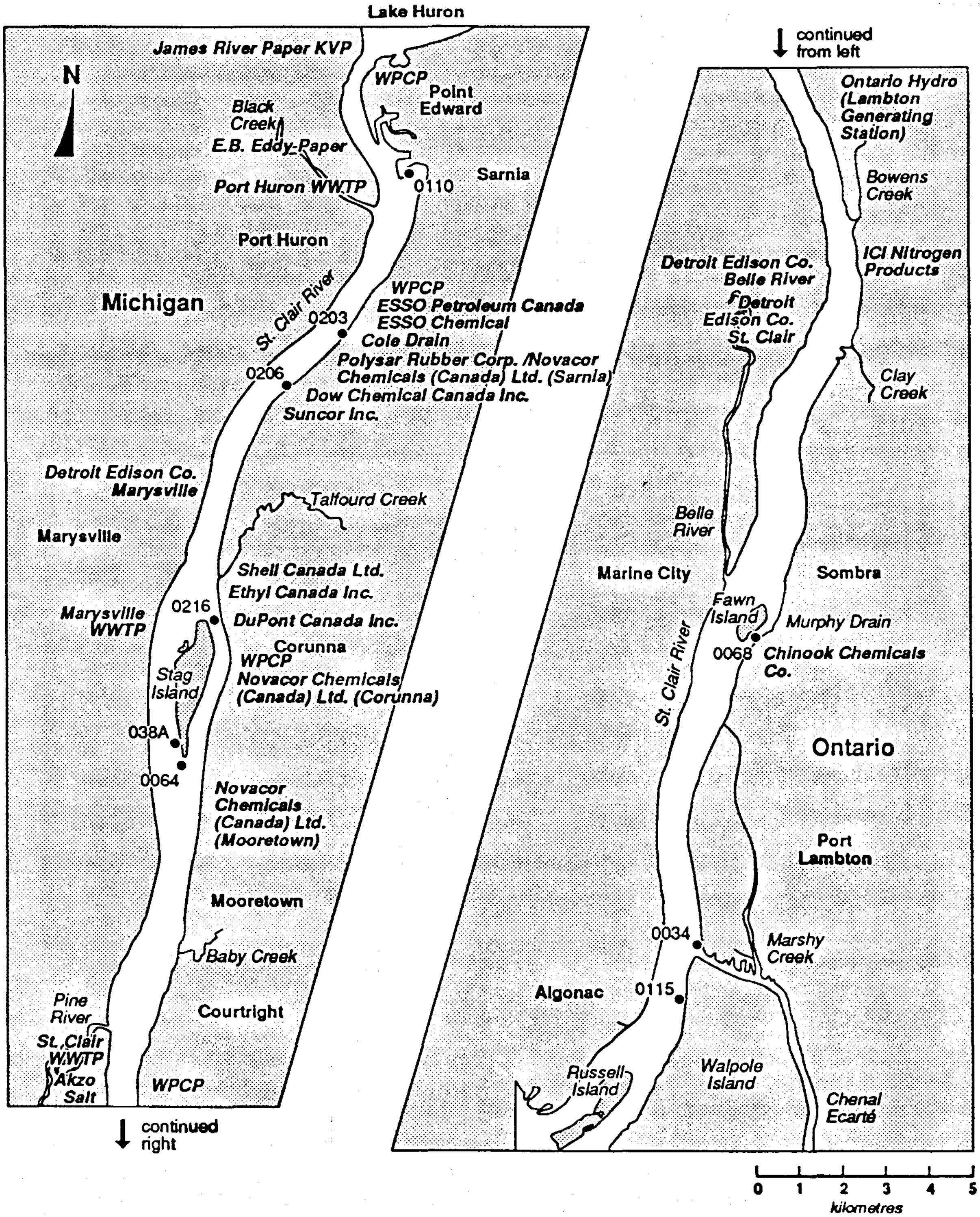
The sources of many of the organic contaminants to the St. Clair River can be located from data on body burdens in benthic macroinvertebrates. Unfortunately little data exist on the relationships between body burdens (especially of complex mixtures of organic contaminants) and sublethal and lethal effects on biota. It has not been explicitly proven that the body burdens of these substances in benthic macroinvertebrates of the St. Clair River are the cause of sublethal effects or that the absence of species from the most contaminated areas is due to contaminant uptake. However, the known relationships between

Figure 6.35

St. Clair River Remedial Action Plan

Coincident sediment-water and benthic (Hexagenia spp.) sampling locations undertaken for the MISA Pilot Site Investigation during 1986

(OMOE 1990a)



environmental contaminant concentrations and body burdens, and between environmental contaminant concentrations and sublethal or lethal effects of persistent organic contaminants, as well as the changes in benthic community composition in the more contaminated reaches of the river, suggest that there may be causative relationships.

6.3.3.3 Macrophytes

Biomass drift, the drift of living plant material, occurs throughout the St. Clair River and may aid in the dispersal of contaminants within the river and their transport into Lake St. Clair (Edsall et al. 1988b). However, there are few data on contaminant levels or trends in either submerged or emergent macrophytes of the St. Clair River. Samples of several submerged species (*Myriophyllum spp.*, *Vallisneria spp.* and *Potamogeton gramineus*) were collected in 1986 for analysis as part of the St. Clair River MISA Pilot Site Investigation (OMOE 1990a). Macrophytes collected between Sarnia and Stag Island for this study contained measurable levels of octachlorostyrene, hexachlorobutadiene, pentachlorobenzene, hexachlorobenzene and the pesticide metabolites p,p'-DDE and heptachlor epoxide. All contaminants were within the range <0.001 to 0.038 $\mu g/g$. However, the results were considered difficult to interpret.

Difficulty in interpretation resulted from the method of sample preparation which was found to affect concentrations of octachlorostyrene and hexachlorobutadiene. In addition, the station representing Sarnia Bay, which is located upstream of most of the industrial complex, was found to be contaminated with industrial organic chemicals including octachlorostyrene and hexachlorobenzene.

6.3.3.4 Fish

Draft fish community goals and objectives for Lake St. Clair and connecting waters were developed by the Ontario Ministry Natural Resources and the Michigan Department of Natural Resources for presentation at the Great Lakes Fish Commission meeting in 1990. These draft guidelines have recommended the following overall fish community goal for the Lake St. Clair, St. Clair-Detroit River system:

> "To ensure a community with walleye as the top predator based on a foundation of stable self-sustaining stocks and provide from that community an optimum contribution of fish, fishing opportunities and associated benefits to meet societal needs."

A number of general objectives and species-specific objectives for the system are also presented in the Draft Fish Community Goals and Objectives document. Those which are most relevant to the St. Clair River AOC are:

- achieve no net loss of the productive capacity of habitats supporting Lake St. Clair, St. Clair-Detroit Rivers fisheries;

- restore the productive capacity of habitats that have suffered damage; and

- reduce contaminants in all fish species to levels below consumption advisory levels.

The draft document also identifies the loss of habitat and productivity due to marsh conversion, water level fluctuations, dredging and deposition of dredged materials and the impacts of contaminants as future issues that may have a negative impact upon attainment of fish community goals and objectives.

Griffiths et al. (1991) note that, overall, the present fish community in the St. Clair River and delta appears well balanced and healthy. There is a large and diverse forage base for seasonal and resident species. They also note that the fish fauna appear to be able to fully utilize all energy sources including benthos, zooplankton, algae and macrophytes. Hamilton (1987) reported that the St. Clair River had the most abundant, diverse and healthy fish community of all the 17 Canadian and binational Areas of Concern. He based the evaluation of fish communities on the Integrated Biotic Index which is developed by assigning scores to various factors related to species richness, trophic composition, and fish abundance and health. Hamilton (1987) rated the fish community of the St. Clair River as having a "fair" to "good" rating based on collection from eleven runs. One exception was found near the northwest shore of Stag Island which was rated as "poor". It is not known if this was due to a sampling anomaly or related to physical and or chemical effects in this area.

6.3.3.4.1 Metal Contaminants in Fish

Mercury contamination of fish stocks has long been a problem in the St. Clair River and Lake St. Clair. During the 1950s and 1960s, Dow Chemical discharged an estimated total of 100,000 kg (220,500 lb) of mercury into the river (UGLCCS 1988). This led to the closure of the Lake St. Clair commercial fishery in 1970 as well as fish consumption advisories for anglers. Discharges of mercury were controlled following the discovery of this problem, and residues in fish have subsequently declined.

In 1970, maximum mercury concentrations in the edible portion of walleye from the St. Clair River were 2.5 $\mu g/g$ (UGLCCS 1988, Vol. II, p. 241). Current mercury concentrations for walleye up to 45 cm (17.6 in) in length are less than the Ontario fish consumption guideline of 0.5 $\mu g/g$ throughout the river and are thus suitable for unlimited consumption (OMOE/OMNR 1990). Large reductions were reported for mercury concentrations in northern pike and white bass between 1970 and 1987 by UGLCCS (1988, Vol. II, p. 241). Neither species is currently restricted for human consumption (OMNR/OMOE 1990). Mercury restrictions currently in effect are largely the result of persistent mercury concentrations in the flesh of larger, older top predator fish. This is most evident in walleye due to the large number of year classes, but is also evident in pike and muskellunge. White bass, while predatory, would not be expected to have the longevity to reveal this trend.

Ontario 1990 fish consumption guidelines and the contaminant for which restrictions are defined are provided in Table 6.40 for five locations along the St. Clair River. These guidelines are for fish collected during 1985 based on analyses which are presented in Appendix 6.4. Downstream of the Blue Water Bridge in Sarnia, there are no restrictions on northern pike, yellow perch or carp; at Stag Island, there are no restrictions on rock bass, yellow perch, white suckers or walleye, and at the Lambton Generating Station, there are no restrictions on yellow perch. At Port Lambton there are no restrictions on yellow perch, white bass or walleye. The only fish which should not be consumed at all are walleye larger than 55 cm (21.5 in) that are caught immediately downstream of the Blue Water Bridge. Fish shown as having consumption restrictions (i.e., consumption guideline classes 1 through 3 in Table 6.40) should not be consumed at all by children under 15 years of age and women of child bearing age. More recent (1991) collections have been made and the results should be available in time for the 1992 Guide to Eating Ontario Sport Fish.

Results from fish collections in the St. Clair River at Algonac, St. Clair and Port Huron, as part of Michigan's Fish Contaminant Monitoring Program (FCMP; MDNR 1990) are summarized in Table 6.41. The analytical results are provided in Appendix 6.5. Results indicate that mercury concentrations are below the Michigan Department of Public Health trigger levels (0.5 $\mu g/g$), the GLWQA Specific Objectives (0.5 $\mu g/g$) and the Health and Welfare Canada limits (0.5 $\mu g/g$) for fish tissue. The Health and Welfare Canada limit for lead (1.0 $\mu g/g$) was also not exceeded. The sport fish were collected between July 1983 and July 1986.

The Michigan Department of Public Health has recommended restricted consumption (no more than one meal per week) of gizzard shad over 25 cm (10 in) and freshwater drum over 30 cm (12 in) throughout the St. Clair River, based on mercury and PCBs. In addition, the restriction advisory indicates that nursing mothers, pregnant women, women who intend to have children and children aged 15 years and under should not consume gizzard shad over 25 cm (10 in) and should consume no more than one meal a month of freshwater drum over 30 cm (12 in). It also recommended not to consume carp from anywhere in the river.

Table 6.40 Sport fish in Ontario waters of the St. Clair River having fillet concentrations of contaminants in excess of Canadian consumption guidelines as of 1985 (OMNR/OMOE 1990a).

Location	Species	Length (cm)	Contaminant	Concentration ($\mu g/g$)	Consumption Guideline*
Sarnia (downstream of Blue Water Bridge)	walleye	45-55	Mercury	0.5-1.0	1
	walleye	>55	Mercury	>1.5	4
	white sucker	>45	Mercury	0.5-1.0	1
Adjacent to Ethyl Corporation	carp	>45	PCBs	>2.0	3
	white sucker	>45	Mercury	0.5-1.0	1
	freshwater drum	>30	Mercury	0.5-1.0	1
	yellow perch	>30	Mercury	0.5-1.0	1
	walleye	>45	Mercury	0.5-1.0	1
Stag Island	gizzard shad	>30	PCBs	>2.0	3
	freshwater drum	35-45	Mercury	0.5-1.0	1
	freshwater drum	>45	Mercury	1.0-1.5	2
Lambton Generating Station	gizzard shad	>35	PCBs	>2.0	3
Port Lambton	gizzard shad	>25	PCBs	>2.0	3

* 1. 0.2 kg/week for long-term consumption; 2.3 kg over 1 week vacation.
2. 0.1 kg/week for long-term consumption; 0.5 kg over 1 week vacation.
3. 0.5 kg/week for long-term consumption; 0.5 kg over 1 week vacation.
4. none should be eaten.

None of the fish in categories noted should be consumed by children under 15 years of age and women of childbearing age.

Total lead residues in young-of-the-year yellow perch in the vicinity of Corunna averaged approximately 4.0 $\mu g/g$ in 1984 (Environment Canada/OMOE 1986). This exceeded the Ontario fish consumption guideline for lead (1.0 $\mu g/g$). Young-of-the-year yellow perch collected at Sarnia (upstream of industrial sources), and downstream of Suncor and at Stag Island averaged between about 0.25 and 0.45 $\mu g/g$ (Environment Canada/OMOE 1986).

The Ethyl Corporation discharges lead to the river. In its organic form, lead is readily bioaccumulated and much more toxic than inorganic lead (Chau et al. 1988). Extensive testing of sport fish for lead below the Ethyl Corporation discharge indicated that concentrations of total alkyl lead were generally less than 0.2 $\mu g/g$ (Appendix 6.4) and, thus, consumption advisories were not required (Ontario fish consumption guideline for lead is 1.0 $\mu g/g$). In 1983 alkyl lead compounds were found to bioaccumulate in white suckers near Ethyl Corporation. Concentrations of individual compounds were up to a factor of 375 (diethyllead) above those in Ethyl's discharge water (Chau et al. 1985). The geometric mean concentrations of total alkyl lead in fish collected in 1983 by Chau et al. (1985) at Stag Island were 0.116 $\mu g/g$ in white sucker, 0.173 $\mu g/g$ in northern pike, 0.026 $\mu g/g$ in walleye and 0.102 $\mu g/g$ in carp (whole fish analysis). Although these concentrations are very low, monitoring should be maintained due to the toxic nature of organolead compounds.

Table 6.41 Concentration of contaminants in fish tissue collected from the St. Clair River (MDNR 1990). Data expressed as $\mu g/g$ unless otherwise noted.

Parameter	Carp[1]	Walleye[2]	Walleye[3]	Carp[3]	Walleye[4]	Drum[4]
2,3,7,8-TCDD	4.3ng/kg	-	6.0 ng/kg[5]	6.0 ng/kg[5]	-	-
Mercury	-	0.10-0.20	0.13-0.46	0.12-0.34	0.12-0.32	0.21
Total Chlordane	-	0.019-0.037	-	-	-	-
Dieldrin	-	0.007-0.015	-	-	-	-
Hexachlorobenzene	-	0.001-0.003	-	-	-	-
Octachlorostyrene	-	0.001[5]	-	-	-	-
Total PCBs	-	0.11-0.22	0.11-0.65	2.214 (mean) 0.060-6.200	0.082-0.530	0.170
Hexachlorobutadiene	-	0.005[5]	-	-	-	-
Hexachlorocyclo-pentadiene	-	0.005[5]	-	-	-	-
Octachlorocyclpentene	-	0.005[5]	-	-	-	-
Pentachlorobenzene	-	0.005[5]	-	-	-	-
Hexachloroethane	-	0.005[5]	-	-	-	-
Toxaphene	-		-	-	-	-
Total DDT	-	0.096 (mean) 0.056-0.146	-	-	-	-
Cadmium	-	0.050-0.092	0.01[5]	0.010[5]-0.016	0.01[5]	0.01[5]
Chromium	-	-	0.1[5]	0.1[5]	0.1[5]	0.1[5]
Copper	-	-	0.4[5]-0.7	0.5-1.1	0.4[5]-0.6	0.5
Lead	-	-	0.1[5]	0.10[5]-0.15	0.1[5]	0.1[5]
Nickel	-	-	0.1[5]	0.1[5]	0.1[5]	0.1[5]
Zinc	-	-	6.0-10.0	9.3-17.6	7.2-10.7	7.4

[1] composite of 5 carp collected 7/27/83 at Algonac - whole fish.
[2] 3 walleye collected 10/10/85 at St. Clair - fillet, skin on.
[3] 10 walleye and 10 carp collected 6/18/86 at Algonac - walleye is fillet, skin on and carp is fillet, skin off.
[4] 10 walleye and 1 freshwater drum collected 7/31/86 at Port Huron - fillet, skin on.
[5] below level of detection with detection concentration indicated.

6.3.3.4.2 Organic Contaminants in Sport Fish

Organic contaminants such as mirex, toxaphene, dioxins and organochlorine pesticides are monitored in fish from the St. Clair River as part of Ontario's Sport Fish Contaminant Monitoring Program (Appendix 6.4). Data for 1985 indicated that concentrations above Health and Welfare Canada, Michigan Department of Public Health or GLWQA Specific Objectives did not occur. However, as shown in Table 6.40, guidelines recommending restricted consumption are in effect for certain size classes of fish (i.e., carp > 55 cm/21.5 in and gizzard shad > 30 cm/12 in) as a result of PCB concentrations in excess of 2.0 μg/g.

Results from fish collections in the St. Clair River at Algonac, St. Clair and Port Huron, as part of Michigan's FCMP are shown in Table 6.41 (Appendix 6.5). Results indicate that organic contaminants in sport fish collected between July 1983 and July 1986 were below Michigan Department of Public Health trigger levels, Health and Welfare Canada limits and GLWQA Specific Objectives in fish tissue for all parameters except total PCBs. Carp tissue collected at Algonac on June 18, 1986 contained an average concentration of 2.214 μg/g total PCBs (range 0.063 to 6.200 μg/g). The Michigan Department of Public Health and Health and Welfare Canada guidelines are 2.0 μg/g. The GLWQA Objective for whole fish to protect birds and animals which consume fish is 0.1 μg/g.

Hexachlorobenzene and octachlorostyrene have been monitored in carp and catfish collected in southern Lake Huron and in Lake St. Clair under the OMNR/OMOE Sport Fish Contaminant Program (OMOE 1990a). Carp collected in 1978 and 1983 to 1986 from southern Lake Huron, from 1979 to 1986 from Lake St. Clair, and in 1985 from Stag Island were analyzed for hexachlorobenzene. Channel catfish were collected for hexachlorobenzene analysis from southern Lake Huron in 1982 to 1985, and from Lake St. Clair in 1976, 1977 and 1979 to 1986. This latter species is useful as a biomonitor because it reflects local conditions and readily bioaccumulates hexachlorobenzene and octachlorostyrene due to its high fat content (OMOE 1990a).

The data for hexachlorobenzene and octachlorostyrene in carp were inconclusive as little or no pattern occurred in comparing upstream (Lake Huron) to downstream (Lake St. Clair) concentrations. This may be due, in part, to their wide ranging movement pattern. The data for channel catfish collected over a considerable number of years, however, clearly shows that the Lake St. Clair specimens contain much more hexachlorobenzene and octachlorostyrene than the same species from collections in southern Lake Huron (OMOE 1990a).

Figures 6.36 and 6.37 illustrate the data for catfish. The average values of hexachlorobenzene in channel catfish collected from Lake St. Clair were 5 to 10 fold higher than those in catfish from southern Lake Huron (Figure 6.36). Average values of octachlorostyrene were consistently about 10 fold higher in Lake St. Clair (Figure 6.37). No clear trends over time are evident. Data from the 1970s may be more a reflection of analytical recovery than quantitatively comparable to later data (OMOE 1990a).

There are no criteria for either hexachlorobenzene or octachlorostyrene in fish to protect human consumers. However, the U.S. EPA has a draft criterion of 0.0064 μg/g for hexachlorobenzene with an associated cancer risk of 10^{-6} for the protection of humans who eat fish. It is based on average consumption levels of 6.5 g/day, however, special consideration needs to be given to individuals who consume greater quantities of fish. Lake Huron catfish collected during 1984 and 1985 slightly exceeded this draft EPA value, whereas, the average values for Lake St. Clair catfish, in all years since 1979, greatly exceeded this value (Figure 6.36).

The EPA draft hexachlorobenzene consumption level was adjusted by OMOE (1990a) to account for the Health and Welfare Canada risk factor (10^{-5}) and for higher average consumption levels of Ontario anglers in order to compare concentrations in these fish with possible consumption concerns. The resulting hexachlorobenzene value is 0.017 μg/g. This number is used for comparative purposes only and has no

Figure 6.36

St. Clair River Remedial Action Plan

Comparison of average concentration of hexachlorobenzene in channel catfish from Lake Huron and Lake St. Clair from 1976 through 1986 (average for all size classes)

(OMOE 1990a)

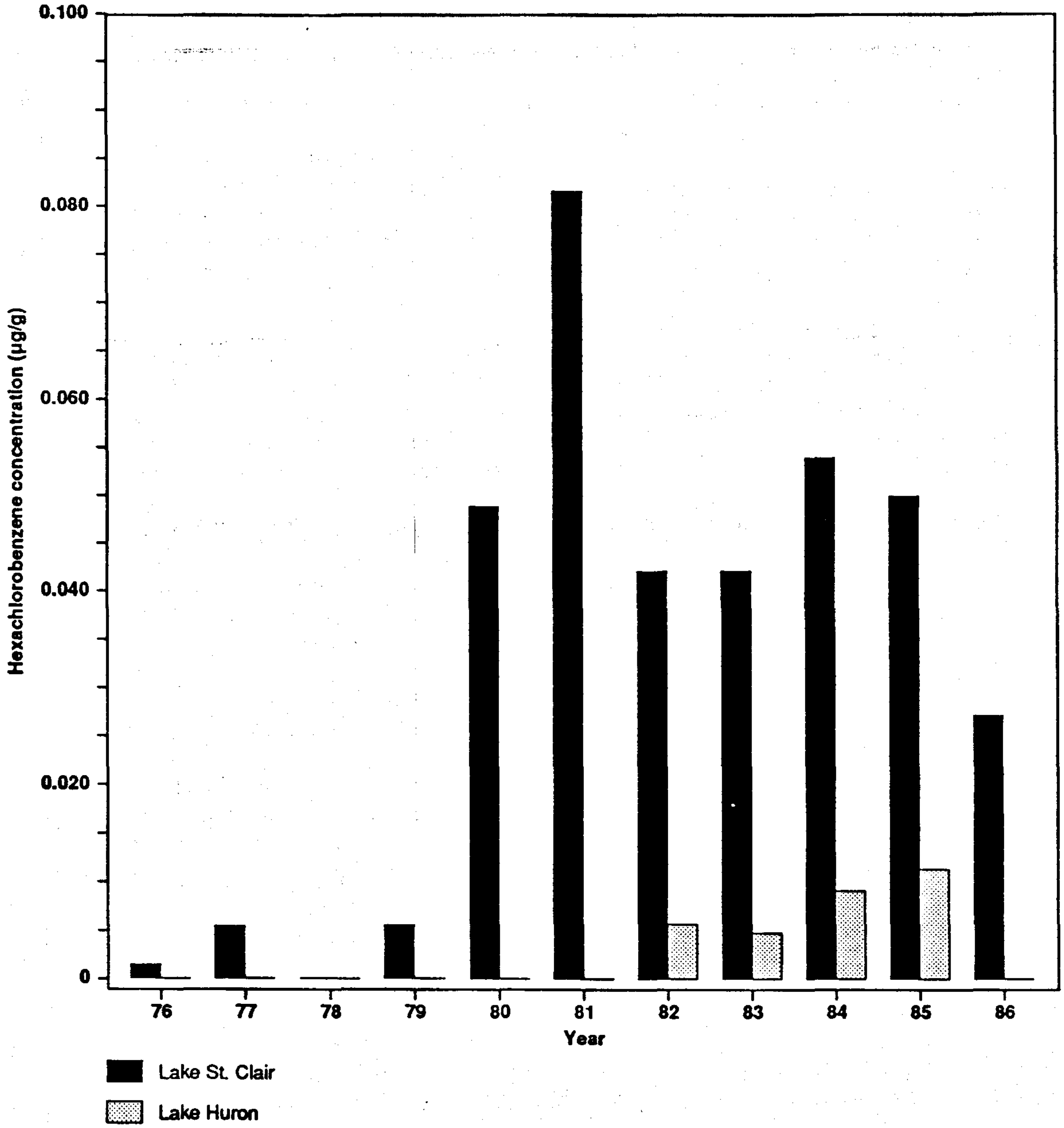
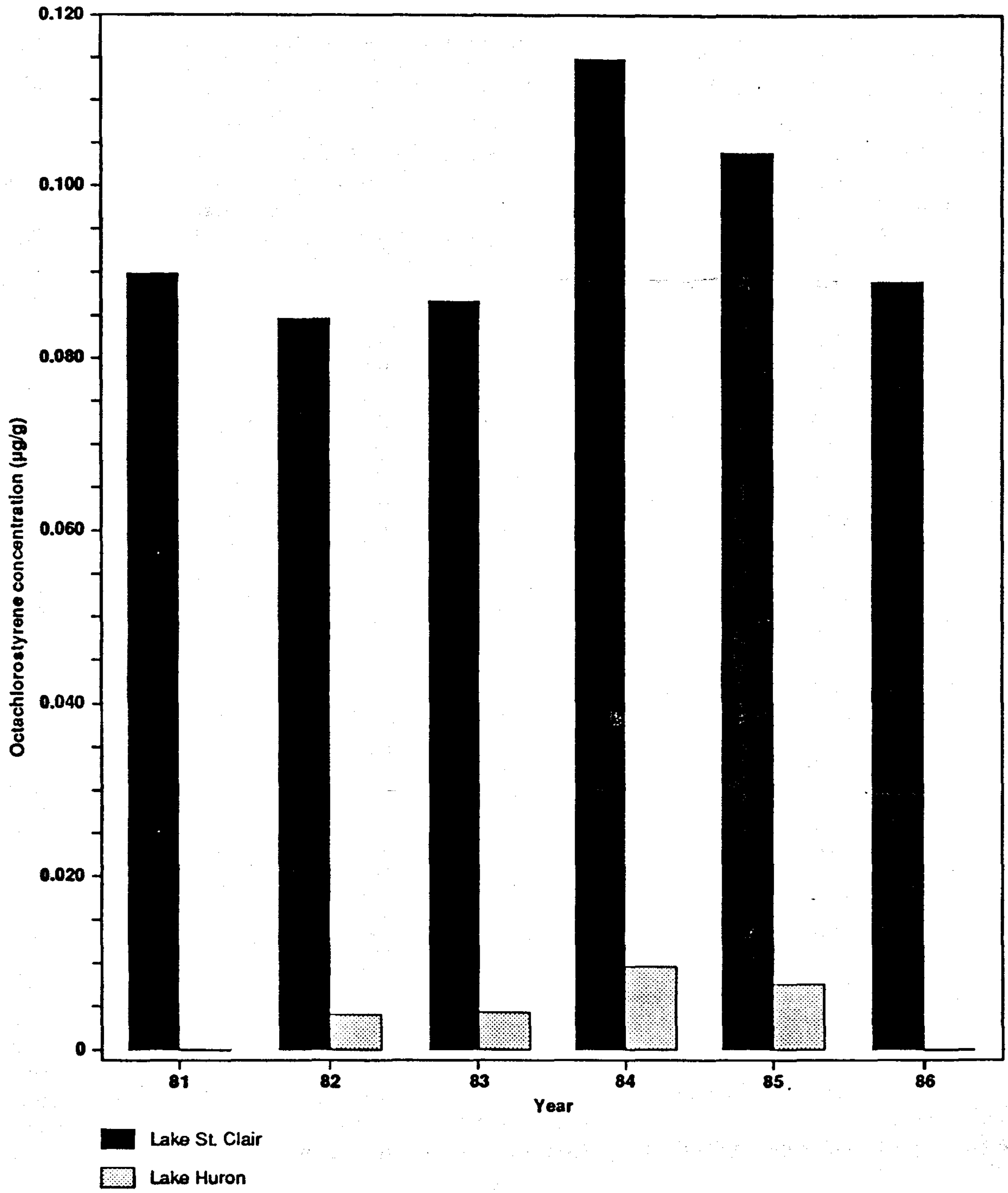


Figure 6.37

St. Clair River Remedial Action Plan

Comparison of average concentration of octachlorostyrene in channel catfish from Lake Huron and Lake St. Clair from 1981 through 1986 (average for all size classes)

(OMOE 1990a)



significance with regard to consumption advisories. Lake Huron catfish did not exceed this value during any year, however, Lake St. Clair catfish collected from 1980 through 1986 had annual average concentrations well in excess of this value (Figure 6.36).

Newell et al. (1987) developed a criterion for the protection of piscivorous wildlife based on octachlorostyrene in fish flesh (0.02 μg/g). The average value of octachlorostyrene in carp exceeded this guideline in all years at all locations in the St. Clair system except southern Lake Huron in 1986 (OMOE 1990a). The average concentration in channel catfish from Lake St. Clair exceeded this guideline by 4 to 6 times in all years (Figure 6.37). Channel catfish from Lake Huron did not exceed the 0.02 μg/g guideline.

6.3.3.4.3 Organic Contaminants in Juvenile Fish

Young-of-the-year spottail shiners from the St. Clair River and Lake St. Clair have been collected and analyzed for organochlorines, chlorinated pesticides and dioxins and furans by OMOE since 1978. Due to their limited movement in the first year of life, these fish serve as a useful biomonitoring organism.

Data for several contaminants are shown in Table 6.42. Additional data for hexachlorobutadiene and hexachloroethane are not shown but were generally below detection. The only exception occurred in samples collected in 1986 offshore of the Suncor Refinery and Lambton Generating Station. Emerald shiners at the Suncor and Lambton Generating Station sample locations had mean concentrations of hexachlorobutadiene and hexachloroethane of 0.07 μg/g and 0.036 μg/g, respectively. OMOE undertook a comparison of young-of-year spottail shiners, emerald shiners, and yellow perch at site locations in Ontario and the states of New York and Michigan. A statistical comparison of contaminant levels, indicates that spottail and emerald shiners are typically not comparable. It is expected that these differences are due to habitat selection. In general spottail shiners reveal higher contaminant levels in areas where local contaminant sources occur, due to their preference for nearshore habitat area. These two species would be more comparable if there was uniform contamination, i.e., no point sources in the vicinity (Suns et al. 1991).

The concentration patterns for PCBs, hexachlorobenzene and octachlorostyrene are similar having low to nondetectable concentrations in juvenile fish at the head of the river and in Mitchell Bay of Lake St. Clair. Highest concentrations of these contaminants occurred adjacent to and downstream of the Sarnia industrial complex (Suncor and Lambton Generating Station sites, Table 6.42). Detectable levels occurred as far downstream as the Chenal Ecarte and South Channel in the delta.

Comparison of contaminant levels with the New York State criteria for protection of piscivorous wildlife (Newell et al. 1987) indicates that the hexachlorobenzene guideline (0.33 μg/g) was never exceeded. The octachlorostyrene guideline (0.02 μg/g) was exceeded in every year at the Suncor, Lambton Generating Station and South Channel stations as well as in 1983 at Chenal Ecarte. The total PCB Great Lakes Water Quality Agreement Specific Objective for whole fish to protect piscivorous wildlife (0.1 μg/g) was exceeded in 1985, 1986 and 1988 at the Lambton Generating Station as well as in 1983 at Suncor and in 1985 at Mitchell Bay. The Health and Welfare Canada limits and Michigan Department of Public Health Trigger Levels for the protection of human consumers (2.0 μg/g) were not exceeded at any station during any year.

Concentrations of octachlorostyrene, hexachlorobenzene, total PCBs and total DDT in juvenile fish generally declined throughout the monitoring period. Hexachlorobenzene residue concentrations in the 1987 spottail shiner collections at Lambton Generating Station were significantly ($p < 0.01$) lower relative to the 1985 and 1986 collections. However, PCBs were almost 75 percent higher in 1988 than in 1987. Octachlorostyrene residues in the 1987 collections were also significantly ($p < 0.01$) lower than those of 1985 (OMOE 1990a) and continued to decline in 1988. The database is too small for proper trend assessment for the other collection sites and for hexachlorobutadiene and hexachloroethane at all sites.

Table 6.42 Means and standard deviations (±) for total PCBs, hexachlorobenzene (HCB), octachlorostyrene (OCS), total dichlorodiphenyltrichloroethane (DDT), total chlordane, 2,3,7,8-tetrachlorodibenzo-p-dioxins (TCDD) and total pentachloro-dibenzofurans (PCDF) concentrations in young-of-the-year spottail shiners from the St. Clair River and Lake St. Clair. Values represent composite fish analyses ($\mu g/g$), wet weight (Suns 1987 and Suns et al. 1991).

Sample Location	Year	No. of Samples	Fish Size (mm)	% Fat	PCBs	HCB	OCS	Total DDT	Total Chlordane	2,3,7,8-TCDD	Total PCDF
					Lake Huron						
Port Huron (Mich.)	1986	5	50 ±3	6.0 ±0.7	0.067±.038	0.003±.001	0.004±.002	0.018±.012	ND	NA	NA
					St. Clair River						
Point Edward	1986*	2	60	5.8	-	0.007	0.013	-	-	-	-
Suncor	1983	4	46 ±7	2.8 ±0.3	0.146±.029	0.231±.026	0.560±.148	0.016±.004	0.003±.001	-	-
	1985*	5	66 ±8	3.7 ±0.4	-	0.069±.043	0.030±.019	-	-	-	-
	1986*	3	59 ±5	5.0 ±0.8	-	0.025±.006	0.031±.006	-	-	-	-
Lambton Generating Station	1985	4	62 ±4	3.4 ±0.4	0.422±.152	0.060±.013	0.081±.022	0.006±.005	ND	ND	0.000274
	1986	5	55 ±4	2.8 ±0.6	0.283±.066	0.031±.013	0.104±.046	0.010±.005	ND	NA	NA
	1987	7	66 ±4	5.0 ±0.7	0.081±.012	0.013±.002	0.035±.003	0.017±.010	0.002±.001	NA	NA
	1988	6	61 ±2	3.7 ±0.4	0.148±.023	0.008±.001	0.023±.005	0.003±.004	ND	NA	NA
South Channel	1982	7	59 ±7	2.0 ±0.3	0.071±.025	0.013±.007	0.095±.010	0.004±.003	0.011±.008	NA	NA
	1986	6	52 ±6	2.0 ±0.3	0.079±.031	0.012±.002	0.049±.009	0.008±.004	ND	NA	NA
Chenal Ecarté	1983	7	57 ±4	1.5 ±0.1	0.062±.009	0.010±.003	0.028±.008	0.010±.001	ND	-	-
	1987	7	53 ±4	1.6 ±0.2	ND	0.006±.001	0.018±.006	0.005±.002	0.004±.002	-	-
					Lake St. Clair						
Mitchell Bay	1978	8	54 ±3	1.8 ±0.2	0.094±.050	ND	NA	0.024±.015	0.007±.003	NA	NA
	1979	7	55 ±5	1.0 ±0.2	ND	ND	0.030	0.011±.003	0.003±.001	NA	NA
	1982	7	58 ±5	2.2 ±0.2	0.033±.014	0.001±0	0.002±0	0.004±.004	TR	NA	NA
	1984	7	58 ±6	2.4 ±0.4	0.038±.032	ND	ND	0.004±.003	TR	NA	NA
	1985	6	61 ±5	3.4 ±0.8	0.105±.045	0.010±.003	0.013±.004	0.007±.007	ND	NA	NA
	1986	7	57 ±5	1.4 ±0.1	TR	0.002±.002	0.002±.001	0.004±.001	ND	NA	NA
	1987	7	58 ±4	1.8 ±0.1	0.400±.026	0.002±.001	0.005±.004	0.007±.002	ND	NA	NA
Detection Limits					0.02	0.001	0.001	0.001	0.002	0.000004	0.000009

* Emerald shiners; ND = Not detected; NA = Not analyzed; - = Data not available.

Tetrachloroethylene residues in young-of-the-year emerald shiners collected in 1985 below the industrial complex were much elevated (Table 6.43). These residue increases were associated with a major spill of tetrachloroethylene from Dow Chemical on August 13-16, 1985 (OMOE 1990a). Carbon tetrachloride residues in the 1986 shiner collections from the same sites were detected in only one of the samples (Table 6.42).

Table 6.43 Volatile hydrocarbon residues in young-of-the-year emerald shiners from the St. Clair River (values in $\mu g/g$ wet weight) (OMOE 1990a).

Sampling Site	Year	n	Tetrachloroethylene	Carbon Tetrachloride
Point Edward	1986	1	T	ND
Below Suncor	1985	1	0.38	ND
	1986	1	0.031	0.004
Lambton	1985	1	0.22	ND
Generating Station	1986	1	0.012	ND
Port Lambton	1985	1	0.32	ND
	1986	1	0.004	ND
South Channel	1986	1	ND	ND

T = Trace; ND = Not detected

6.3.3.4.4 Lambton Industrial Society Biomonitoring Program

Between May 1987 and June 1989, the Lambton Industrial Society undertook a biomonitoring program of the St. Clair River using rainbow trout fingerlings held in flow-through tanks upstream and downstream of Sarnia's industrial complex (Pollutech 1989). The fish were maintained at this location for two years, during which growth rates were monitored, health was assessed by both visual and microscopic pathological examination and spawning potential was evaluated by monitoring gonadal development.

Fish held at the downstream location south of Corunna had an average weight of 3,080 g (6.79 lb) and an average length of 52.2 cm (20.4 in) after the two year period. In comparison, those held at the upstream location (at Point Edward) had similar growth statistics with an average weight of 2,896 g (6.38 lb) and an average length of 53.2 cm (20.7 in).

Results of pathological examinations are shown in Tables 6.44 and 6.45. There were no substantial pathological differences between fish held at the two sites. However, during the final examination (June 6 1989), a microscopic abnormality was observed in the gills of two of the fish held downstream. The surface epithelium of the gill lamellae had been totally disrupted. The cause was not biologically related but, in the opinion of the aquatic pathologist, this type of disruption was related to "some sort of chemical presence within the water" (Pollutech 1989). The liver of one fish held at the downstream location also showed signs of possible early neoplastic tissue changes, however, this finding is not statistically significant.

Fish did not reach full spawning potential during the two year holding period, however, there were no obvious differences in gonad development between fish held at the two sites.

Table 6.44 Summary of visual pathological examinations of rainbow trout (*Onchorynchus mytiss*). Fish were held in flow through system upstream (vicinity of the Blue Water Bridge) and downstream (near the Lambton Generating Station) of the Sarnia industrial complex. Starting fish population was 40 fish per tank. The percentage of abnormal fish is reported for each category (from Pollutech 1989).

Parameter	September 28, 1987		January 10, 1988		May 10, 1988		August 19, 1988[1]		June 6, 1989	
	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream
Gross tumours	0	0	0	0	0	0	0	0	0	0
Body form	0	0	0	0	0	20	10	10	10	20
Fin erosion	40	30	10	10	0	0	10	10	50	80
Skin pigmentation	10	40	60	20	30	20	20	0	10	0
Flesh condition	0	0	0	0	0	0	10	10	10	0
Other external										
fins	10	0	0	0	0	0	0	0	0	0
eyes	0	30	0	0	10	10	40	30	20	10
head	0	0	20	80	0	70	50	40	50	70
spine	0	0	10	0	0	0	0	0	10	0
skin	0	0	0	0	0	0	40	60	10	30
Gill condition	10	40	10	0	0	0	20	0	20	10
Visceral fat	50	50	10	10	10	20	0	0	10	20
Internal organs										
thymus	20	20	0	0	0	0	0	0	0	0
G-I tract	30	50	10	0	20	20	10	0	0	0
liver	0	10	0	0	0	0	0	0	0	0
swim bladder	0	10	0	0	0	0	0	0	0	0
spleen	0	0	10	0	10	0	40	10	0	0
heart	10	0	0	0	0	0	0	0	0	0
Gonad condition	0	0	0	0	0	0	0	0	0	0
Pseudobranch	0	0	0	0	0	0	10	0	0	0

[1] Examinations consisted of 10 fish from each station which were transported live to the Guelph laboratory, however, on August 19 all 20 died en route and only some of the specimens could be examined.

6.3.3.4.5 Fish Tumours

External lesions found on fish, particularly walleye, have caused concern among anglers in recent years. Johnson et al. (1990) compared contaminant residues in male walleye taken from Lake St. Clair and having grossly visible skin lesions to unaffected fish from the same location. The skin lesions were diagnosed histologically to be lymphocystis and dermal sarcoma, both of which are the result of viral skin diseases. Contaminants measured from the edible muscle portion included PCBs, organochlorine pesticides, mercury, heavy metals, chlorinated phenols and chlorinated benzenes. Johnson et al. (1990) concluded that these diseases were not likely the result of variable exposure to the persistent contaminants measured in the study. Natural causative factors are not completely understood. Dense congregations of fish, such as are found during spawning events, appears to play a role as does water temperature. Seasonality may also be important.

Lymphocystis and dermal sarcomas are not generally fatal to the infected fish and practically all will recover from their infections. They pose no threat to consumers and there is no direct evidence linking them to the pollution of this system (Bill Bryant, MDNR, pers. com.).

Table 6.45 Summary of microscopic pathological examinations of rainbow trout (*Onchorynchus myiss*). Fish were held in flow through system upstream (vicinity of the Blue Water Bridge) and downstream (near Lambton Generating Station) of the Sarnia industrial complex. Initial fish populations were 40 per site. The percentage of abnormal fish is reported for each category (from Pollutech 1989).

Parameter	September 28 1987		January 10 1988		May 10 1988		August 19 1988[1]		June 6 1989	
	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream
Gill	0	0	0	0	60	50	3 of 5	0 of 2	30	40
Kidney	0	10	0	0	0	0	2 of 8	0 of 5	0	10
Liver	40	40	90	90	10	0	1 of 8	0 of 6	0	10
Spleen	30	20	100	70	20	50	3 of 10	6 of 10	0	0
G-I tract	0	0	0	0	0	0	0 of 0	0 of 0	0	0
Pancreas	0	0	0	0	0	0	0 of 0	0 of 0	0	0
Skin	0	0	0	0	0	10	4 of 10	5 of 9	10	0
Muscle	0	20	0	0	10	20	0 of 6	0 of 6	0	0
Heart	0	0	0	0	0	0	0 of 9	0 of 9	10	0
Brain	0	0	0	0	0	0	0 of 10	0 of 10	0	0
Other lesions	0	0	0	0	0	0	0 of 10	0 of 10	0	0
Blood smear	0	0	0	0	50	40	0 of 9	0 of 0	10	10

[1] Examinations consisted of 10 fish from each station which were transported live to the Guelph laboratory, however, on August 19 all 20 died en route and only some of the specimens could be examined.

There have not been any studies to determine the incidence of internal tumours such as hepatic carcinomas of the liver. This type of cancer has been related to environmental contamination (Black et al. 1980, Baumann et al. 1982, Cairns and Fitzsimons 1988). In a study by Pollutech (1989) Rainbow Trout were held in cages for two years upstream and downstream of the Sarnia industrial complex. The fish were examined for growths and microscopic tissue abnormalities. The incidence of abnormalities between fish raised upstream and those downstream was insignificant. Also, examination of the liver tissue revealed no tumours and no significant incidence of neoplastic tissue changes. The liver from downstream fish revealed possible early neoplastic tissue changes however, this condition does not inevitably result in the development of tumours.

6.3.3.5 Wildlife

Wildlife community goals have not been drafted specifically for the St. Clair River AOC, however, strategic planning documents such as the OMNR District Land Use Guidelines and the Southwestern Region (OMNR) Wildlife Strategy provide a broad level of direction for wildlife management on the Ontario portion of the AOC. These planning documents emphasize, *inter alia*, the need to achieve no net loss of remaining wildlife habitat and, where feasible, to rehabilitate degraded habitat.

There is no information on changes in wildlife populations, their usage of the river and associated wetlands, the impact of chemicals on wildlife communities in general, nor of physical habitat changes on mammals, amphibians and reptiles. Historic losses of wildlife habitat due to dredging, infilling, bulkheading, drainage and other means associated with industrial, urban, agricultural and navigational activities within the AOC have only been partially documented (Section 6.2). There is no doubt that significant alterations have occurred since European settlement.

6.3.3.5.1 Contaminants in Wildlife

Contaminant levels in adult snapping turtles collected in 1988 at Walpole Island are shown in Table 6.46. These animals are collected for food by local residents (Glooschenko et al. 1990). Almost all of the DDT present was as p,p'-DDE. PCBs, measured using Aroclor standards 1254 and 1260, constituted no more than 10 percent of the total organochlorine burden. Oxy-chlordane and trans-nonachlor were the principal congeners of chlordane. All contaminants were seen at much higher concentrations in the liver than they were in muscle.

Table 6.46 Contaminant levels in adult snapping turtles taken from Walpole Island in 1988; mean values ($\mu g/g$, wet weight) are given (Glooschenko et al. 1990).

Parameter	Muscle (n=5)	Liver (n=3)
lipid	0.36	3.67
water (%)	77.2	74.6
1,2,4,5-tetrachlorobenzene	<DL	<DL
1,2,3,4-trichlorobenzene	0.00007	<DL
pentachlorobenzene	<DL	<DL
hexachlorobenzene	0.00035	0.00825
octachlorostyrene	0.00099	0.0134
lindane	<DL	0.00017
total PCB (Aroclors 1254 & 1260)	0.0293	1.09
total Chlordane	0.00117	0.0217
total DDT and metabolites	0.00215	0.0319
mirex	0.00011	0.00163
heptachlor epoxide	<DL	0.00395
dieldrin	0.00033	0.00553

No contaminant guidelines have been established for the consumption of turtles, however, the Ontario Ministry of Natural Resources (OMNR) recommends that people should 'use prudence' with respect to the regular consumption of adult turtle meat derived from Great Lakes waters. PCB concentrations in both muscle and liver of turtles analyzed by the OMNR were below the Health and Welfare Canada and Michigan Department of Public Health guideline of 2.0 $\mu g/g$ established for the protection of human consumers of fish. However, the recommendation was based on concentrations in the liver portion which exceeded (by a factor of 10) the Great Lakes Water Quality Guideline of 0.1 $\mu g/g$ for the protection of birds and animals which consume fish. Turtles from Walpole Island were included in the OMNR analyses.

Chlorinated hydrocarbon contamination of ducks and muskrat of Walpole Island has been examined in response to concerns about the consumption of wild meats by members of the Walpole Island Band (Great Lakes Institute 1987). A study between July and December of 1986 examined 49 ducks collected by hunters including 15 non-migratory mallards; 10 migratory mallards; 16 non-migratory redheads; 2 migratory redheads and 6 migratory ruddy ducks. Both liver and breast muscles of these birds were analyzed for octachlorostyrene, hexachlorobenzene, pentachlorobenzene and PCB congeners 28, 101 and 180.

Results of these analyses are shown in Table 6.47. In all species tested, octachlorostyrene residues were greater than those of any of the other contaminants examined. PCB congeners were found to be present in

Table 6.47 Concentrations of hexachlorobenzene (HCB), octachlorostyrene (OCS), pentachlorobenzene (QCB) and three PCB congeners in Walpole Island ducks collected between July and December of 1986; mean values are provided (μg/g) (from Great Lakes Institute 1987).

	Mean Weight of Sample (g)	QCB	HCB	OCS	PCB-28	PCB-101	PCB-180
Non-migratory Mallards (N=15)							
Liver	6.72	0.00153	0.02959	0.11533	0.00176	0.00116	0.00394
Muscle	10.02	0.00055	0.00714	0.01171	0.00044	0.00022	0.00152
Migratory Mallards (N=10)							
Liver	4.80	0.00041	0.00870	0.05608	0.00020*	0.00007*	0.00110
Muscle	9.63	0.00047	0.00482	0.00167	0.00011*	0.00002	0.00042
Non-migratory Redheads (N=16)							
Liver	5.76	0.00118	0.02001	0.0856	0.00040	0.00043	0.00146
Muscle	9.82	0.00077	0.01076	0.00478	0.00023	0.00010*	0.00097
Migratory Redheads (N=2)							
Liver	4.90	0.00049	0.00204	0.01893	0.00001*	0.00036	0.00008*
Muscle	10.80	0.00082	0.00166	0.00349	0.00017*	0	0.00007*
Migratory Ruddy Duck (N=6)							
Liver	5.65	0.00019*	0.00143	0.00463	0.00031	0.00006*	0.00021
Muscle	10.04	0.00085	0.00141	0.00130	0.00038	0.00008*	0.00072

*Below limit of quantification.
Note: PCB congener data shown here are not comparable to PCB data reported as Aroclors (Tables 6.46, 6.48)

relatively small amounts. Liver concentrations were significantly ($p < 0.05$) greater than those in muscle tissue. A comparison of contaminant levels in livers revealed that resident birds were significantly ($p < 0.05$) more contaminated than migratory birds for all parameters except PCB congener 180. However, there was no significant difference in the contaminant burden of open-water (i.e., redheads) and marsh ducks (i.e., mallards).

Muskrats were collected at four locations on Walpole Island. Results of contaminant analysis on fat, liver and muscle are shown in Table 6.48. Some significant ($p < 0.05$) differences in contaminant concentrations in the fat portion were found between areas. No significant differences were found among the populations with regard to any contaminants in muskrat liver or muscle. Contaminant levels in liver and muscle tissue were found to be much lower than in ducks.

The Great Lakes Institute study (1987) concluded that the results indicate that organic compounds, particularly octachlorostyrene and hexachlorobenzene, are moving down the St. Clair River and being trapped within the marshlands of Walpole Island. They note that the data for octachlorostyrene confirms earlier studies which identified the primary source as industrial chlorine manufacturers in Sarnia. The fact that muskrat populations were less contaminated than ducks, indicated that there must be discrete entry

Table 6.48 Mean concentrations of hexachlorobenzene (HCB), octachlorostyrene (OCS), PCB Aroclors 1242, 1260 and 1254 and total PCB ($\mu g/g$) in muskrats collected at four locations on Walpole Island Indian Reserve (from Great Lakes Institute 1987).

Collection	Tissue	HCB	OCS	1242	1260	1254	Total PCB
Johnson Channel (lower half)	Fat (N=2)	0.00210	0.00025	ND	0.01163	0.0002	0.00806
	Liver (N=3)	0.00017	ND	ND	0.00114	ND	0.0015
	Muscle (N=1)	0.0007	ND	ND	ND	0.00044	0.00291
St. Anne's Marsh (bottom part)	Fat (N=2)	0.00087	0.0008	ND	0.0318	0.00018	0.02266
	Liver (N=2)	ND	ND	ND	0.00129	0.00011*	0.00251
	Muscle (N=2)	0.00007*	ND	ND	ND	0.00011	0.0011
North tip of Bassett Island	Fat (N=3)	0.00711	0.001	ND	0.00932	0.00023	0.03589
	Liver (N=3)	0.00017	ND	ND	ND	ND	0.00073
	Muscle (N=3)	0.00016*	0.00005*	ND	ND	ND	ND
North half of Bassett Island	Liver (N=2)	0.00048	0.00022	ND	0.00008*	ND	0.00183
	Muscle (N=2)	0.00015*	0.00012*	0.00008	ND	0.00007*	0.00055

ND - Not detected.
* = Below limit of quantification.

points for the contaminants into the food web. High residue levels in duck livers could not be related to any short or long term effects with regard to duck health.

The Canadian Wildlife Service conducts a contaminants monitoring program utilizing herring gull eggs collected from various Great Lakes' colonies. Additional studies of liver contaminant levels in wild and domestically- raised birds have also been undertaken. Weseloh and Struger (1989) reported on results of egg and liver tissue analyses of several different species in the lower St. Clair River and delta. The following collections were reported on: herring gull eggs from the lower St. Clair River in 1987 and eggs of black-crowned night herons and Forster's terns from Bassett Island in 1986; three species of wild ducks collected from the lower St. Clair River area during the winter of 1985/86; and domestically-raised, chemically clean Pekin ducks which were released at Seaway Island in the delta.

The results of the Weseloh and Struger (1989) studies of herring gull, black-crowned night heron and Forester's tern egg collections for the St. Clair River AOC are shown in Table 6.49 and compared to other locations in the Great Lakes. In herring gull eggs, PCB values from the St. Clair River were intermediate to the higher concentrations in eggs from Fighting Island in the Detroit River and from Lake Erie and the much lower concentrations in eggs from the Niagara River and Lakes Ontario and Superior. Herring gull eggs from the lower St. Clair River had by far the highest concentrations of hexachlorobenzene of all sites. The concentration of DDE in the St. Clair herring gull eggs were intermediate whereas dieldrin was the highest of the six sites.

In eggs from black-crowned herons and Forster's terns collected from Bassett Island in the delta, all contaminants were either at the lower end or intermediate to the other sites reported (Table 6.49).

The results for wild ducks from the St. Clair River (Table 6.50) indicate that the goldeneyes showed substantial accumulation through the winter, suggesting that food resources in the AOC were more contaminated than in the area from which they had come. The mergansers, however, showed little or no change, suggesting that the contaminant levels in their diet obtained from the AOC were not greatly different

Table 6.49 Total PCBs, dichlorodiphenyldichloroethylene (DDE), octachlorostyrene (OCS), dieldrin, hexachlorobenzene (HCB) and heptachlor epoxide in eggs from herring gulls, black-crowned night herons and Forster's terns collected during 1986 and 1987 from the lower St. Clair River and St. Clair River delta (Bassett Island). Values are in $\mu g/g$ and on a lipid weight basis to facilitate inter-species comparisons (Weseloh and Struger 1989).

Location	Total PCBs	DDE	OCS	dieldrin	HCB	heptachlor epoxide	Lipid (%)
Herring Gulls (1987)							
Lower St. Clair River	288	26	1.0	1.90	1.20	0.99	9.1
Fighting Island, Detroit River	425	28	NA	0.99	0.75	0.68	8.0
Unnamed Island Niagara River	146	17	NA	1.60	0.34	0.81	8.9
Snake Island, Lake Ontario	191	32	NA	1.70	0.56	0.92	8.9
Agawa Rocks, Lake Superior	120	24	NA	1.40	0.43	1.20	9.2
Middle Island, Lake Erie	321	20	NA	1.60	0.46	0.88	8.7
Black-Crowned Night Herons (1986)							
Basset Island, St. Clair Delta	149	31	NA	1.20	0.17	0.40	5.8
Middle Island, Lake Erie	261	15	NA	0.67	0.12	0.42	5.1
Unnamed Island, Niagara River	610	60	NA	4.00	1.00	1.20	5.5
Forster's Terns (1986)							
Bassett Island, St. Clair Delta	163	19	NA	1.70	0.56	0.56	7.9
Long Point, Lake Erie	157	17	NA	1.70	0.23	0.54	7.4
Green Bay, Lake Michigan	292	24	NA	ND-3.40	1.30	2.60*	NA

ND = below method detection level
NA = data not available
* = oxy-chlordane + heptachlor epoxide

Table 6.50 Organic contaminants in livers of wild ducks from the lower St. Clair River during early (December) and late (February) winter 1985-86. **Concentrations are in $\mu g/g$ on a lipid weight basis** (Weseloh and Struger 1989).

Parameter	Mallards		Goldeneyes		Mergansers	
	December	February	December	February	December	February
PCBs	18.200	3.540	17.200	30.800	41.000	45.000
octachlorostyrene	11.400	0.988	6.390	18.600	6.200	8.040
hexachlorobenzene	7.280	0.265	4.540	10.000	4.590	4.010
DDE	0.984	0.434	1.460	3.590	6.650	6.480
dieldrin	0.983	0.193	0.890	2.430	2.180	1.770
heptachlor epoxide	0.304	0.121	0.365	1.180	0.696	0.570

from where they had come. In contrast, the contaminant levels in mallards showed a substantial decline over the winter. Assuming the food source for the birds had remained constant, this scenario is consistent with a change in mallard populations between the two sampling periods (i.e., resident birds from the summer or autumn being sampled in December followed by their departure and the arrival of different birds, from cleaner environs, being sampled in February). This is not inconsistent with known migratory habits in mallards of the St. Clair River AOC (Weseloh and Struger 1989).

The domestic duck study of Weseloh and Struger (1989) showed unequivocally that all six compounds were accumulated in the livers of the released ducks (Table 6.51). Concentrations of PCBs, hexachlorobenzene and octachlorostyrene increased by up to five times over a one month period (July-August). However, the three organochlorine pesticide parameters showed consistent decreases in both wet weight and lipid weight determinations between July and August. This decrease may be related to a change in feeding behaviour of the birds or to the dynamics of the compounds within the birds (Weseloh and Struger 1989).

The data available to date indicate that wildlife, including muskrats, turtles and various species of duck, in the St. Clair River delta are contaminated by toxic organic contaminants, particularly octachlorostyrene, hexachlorobenzene and PCBs. Further, accumulation patterns in migratory and introduced ducks as well as concentrations in non-migratory ducks indicate that these chemicals are being derived from within the AOC. Whether or not the measured concentrations will contribute to health problems in humans who consume wildlife is unknown as there are no applicable guidelines currently available.

The Native residents of Walpole Island are dependant on the wildlife and fish of the St. Clair River as a dietary supplement (Great Lakes Institute 1987). A 1986 survey indicated that the most common types of meat eaten by residents of the Walpole Island Indian Reserve were duck (mostly mallard, redhead and teal), eaten by 21.9 percent of households surveyed; deer, 15.6 percent; muskrat, 13.7 percent; and a combination of beaver, turtle, bullfrog, goose, coot and racoon, 12.2 percent (Nin.da.waab.jg Research Centre 1986). Most of the remainder of the wild meat diet consisted of fish (23.8 percent). The study did not identify consumption patterns nor the percentage of wildlife meat which comprises the total diet.

Health and Welfare Canada is working with the Assembly of First Nations and with the University of Toronto to develop a community-based Native peoples' program. The objectives are now being defined by

Table 6.51 Organic contaminants in livers of flightless Pekin ducks under control (aviary) and exposed (Seaway Island) conditions during 1986. Values are based on a single analysis of a pooled sample and are given in $\mu g/g$ on both a wet weight (A) and a lipid weight (B) basis (Weseloh and Struger 1989).

Parameter		Control		Seaway Island	
		June	September	July	August
PCBs	A	0.005	ND	0.129	0.635
	B	0.129	ND	4.300	10.500
octachlorostyrene	A	ND	ND	0.048	0.210
	B	ND	ND	5.100	0.364
hexachlorobenzene	A	<0.0005	ND	0.0480	0.2100
	B	<0.0130	ND	1.6000	3.5000
DDE	A	0.001	0.001	0.011	0.008
	B	0.026	0.029	0.366	0.132
dieldrin	A	ND	0.001	0.010	0.002
	B	ND	0.029	0.333	0.033
heptachlor epoxide	A	ND	ND	0.005	0.001
	B	ND	ND	0.166	0.016
% Lipid		3.9	3.4	3.0	6.0

Native peoples and the Medical Services Branch of Health and Welfare Canada. It is expected that residents of Walpole Island will participate in this program.

There are currently no guidelines for either human consumption of wildlife or wildlife consumption of other wildlife which are applicable to the St. Clair River AOC. However, the Ontario Ministry of Natural Resources warning with respect to the regular consumption of turtle meat was based on data which included samples from turtles collected in the St. Clair delta.

6.3.3.6 Biota Quality Summary

Table 6.52 summarizes the environmental condition of biota in the St. Clair River based on exceedences of guidelines or objectives, including fish consumption guidelines and the Great Lakes Water Quality Agreement Specific Objectives for fish-eating wildlife, as well as on physical impairments. The major findings for each type of biota are summarized below.

Benthic Macroinvertebrates

The benthic health of the St. Clair River has been impacted by contaminants discharged from industrial sources along the Canadian side of the river, particularly in the industrial complex immediately south of Sarnia. This is shown by the existence of severely degraded benthic communities within this zone. In addition, contaminants have been shown to bioaccumulate in mussels and aquatic insects within and downstream of the industrial complex.

Table 6.52 Summary of biotic conditions for the St. Clair River Area of Concern.

Parameter/Concern	Objective/Guideline (μg/g) or Physical Impairment	Type of Biota	Year and Location
Mercury	Fish Consumption-human (0.5)[1]	walleye white sucker freshwater drum yellow perch	1985-at Sarnia and adjacent to Ethyl Corp. 1985-at Sarnia and adjacent to Ethyl Corp. 1985-adjacent to Ethyl and Stag Island 1985-adjacent to Ethyl
PCBs	Fish Consumption-human (2.0)[1]	carp	1985-adjacent to Ethyl 1986-adjacent to Algonac
	Fish Tissue-wildlife (0.1)[2]	gizzard shad	1985-Stag Island, Lambton G.S. and Port Lambton
		carp	1986-adjacent to Algonac
		walleye	1985-adjacent to St. Clair 1986-adjacent to Algonac and Port Huron
		drum	1986-adjacent to Port Huron
		juvenile fish (shiners)	1983-Suncor sampling site (0.146/mean) 1985,1986,1988-Lambton G.S. (0.148 to 0.422/means) 1985-Mitchell Bay
Octachlorostyrene	Fish Tissue-wildlife (0.02)[3]	carp	1979 to 1986-exceeded in Lake Huron 1985-exceeded at Stag Island
		channel catfish	1976,1977,1979 to 1986-exceeded in Lake St. Clair (0.08 to 0.12/means)
		juvenile fish (shiners)	1983,1985,1986-Suncor sampling site (0.03 to 0.56/means) 1985,1986,1987,1988-Lambton Generating Station (0.023 to 0.104/means) 1982,1986-South Channel (0.05 to 0.1/means) 1983-Chenal Ecarté (0.03/mean)
Benthic Macroinvertebrates	Degraded, Impaired, Severely Degraded[4]	benthic community structure	1985 -12 km (7.4 mi) along industrial waterfront from Esso Petroleum downstream to below Allied Chemical.
	Deformities	chironomids	1986 -Chironomid mouth part deformities below Sarnia industrial complex and at Courtright.

Table 6.52 (cont'd)

Parameter/Concern	Objective/Guideline (μg/g) or Physical Impairment	Type of Biota	Year and Location
Fish Health	Community Structure, Species Abundance and Diversity[5]	fish community quality	Overall, the fish community is healthy and well balanced with full utilization of energy sources. However, in 1986 a poor Integrated Biotic Index was noted on the northwest shore of Stag Island based on one sampling run.
Fish and Wildlife	Population Dynamics	lake trout, whitefish and herring	historical-loss throughout river and delta attributed to overfishing, habitat loss.
	Loss of Habitat	marsh-dwelling species	1968 to 1982-41 percent decline in numbers of wigeon, teal and wood ducks of Lake St. Clair marshes (including the delta marshes) during the fall. -79 percent decline in numbers of birds during spring.
		wetland and shoreline habitat	historical-due to filling, draining, dredging and bulkheading for industrial (Sarnia), urban, agricultural and navigational uses.

[1] Based on the Ontario Fish Consumption Guideline (OMOE/H&WC) and the Michigan Department of Public Health fish consumption trigger levels.
[2] Based on the Great Lakes Water Quality Agreement Specific Objective for fish tissue.
[3] Newell et al. (1987).
[4] OMOE (1990a).
[5] Hamilton (1987), based on the 'Integrated Biotic Index'.

Studies of benthic invertebrate community structure from 1968 to 1985 indicate a strong pattern of improving environmental quality on the Canadian side of the St. Clair River. The U.S. side of the river had healthy benthic communities throughout this monitoring period. OMOE (1990a) concluded that the implementation of industrial and municipal abatement programs since the early 1970s has resulted in the reclamation of 9 km (5.6 mi) of the river. Further anticipated improvements in benthic structure will be tested by a repeat of the 1985 investigation. Intensive and extensive surveys were carried out during 1990, however, the results are not yet available. MISA Pilot Site findings indicate that the 1985 impaired zone corresponds closely to the contaminant plume predicted by mathematical models based on 1984 to 1985 loading conditions. Using the 1986 to 1987 loadings, the model results indicate that the impaired zone may be further reduced to approximately 6 km (3.7 mi) (OMOE 1990a)

The data on heavy metal concentrations in benthic fauna are very limited. Due to differences in analytical procedure and species studied, it is not possible to compare the results in order to determine trends over time. Limited data as provided by Persaud et al. (1987) and Pugsley et al. (1988) suggest that the calculation of bioaccumulation factors for heavy metals in mussels and worms based on sediment concentrations alone has limited application. However, the pattern of contamination identified in the results of both Chau et al. (1988) and Pugsley et al. (1988) suggest that lead and cadmium contamination of two species of mussel in the St. Clair River and downstream, are primarily the result of discharges from Canadian sources.

Inputs along the industrial complex south of Sarnia are considered to result in accumulations in the tissue of introduced mussels of: octachlorostyrene; hexachlorobenzene; hexachlorobutadiene; pentachlorobenzene; PCBs; PAHs; chloroform; benzene; ethylbenzene; xylenes; 2,4,5-trichlorotoluene; 1,2,4-trichlorobenzene; 1,2,3,5 trichlorobenzene; 1,2,3,5-tetrachlorobenzene; and 1,2,4,5-tetrachlorobenzene. Inputs to the river between Talfourd Creek and Polysar in Corunna contributed 1,3,5-trichlorobenzene, pentachlorobenzene and 1,2,3,5-tetrachlorobenzene. Accumulations of lead in mussel tissue were found immediately offshore and downstream of the Ethyl Corporation discharge.

The present data base is not sufficient to determine temporal trends regarding body burdens of chemicals in benthic fauna. Mussel studies in the St. Clair delta undertaken in 1982 and 1987, however, suggest that body burdens of octachlorostyrene, pentachlorobenzene and hexachlorobenzene have decreased in this area.

There are no applicable guidelines for organic contaminants in benthic tissue.

Ecosystem improvements, as shown by the reduction in the extent of the severely degraded benthic community zone, are undoubtedly related to reduced loadings of contaminants as a result of effluent controls, particularly since the early 1970s. This evidence provides a strong rationale for the use of controls and the potential for further improvements.

Fish

Mercury, lead, octachlorostyrene, hexachlorobenzene and PCBs have been found in the flesh of sport and/or juvenile fish with concentration patterns indicating sources in the industrial complex south of Sarnia. Concentrations of mercury and PCBs are sufficient in walleye, white sucker, carp, yellow perch, freshwater drum and/or gizzard shad at certain locations to exceed consumption guidelines (Table 6.52). The consumption guideline for lead had not been exceeded as of 1985.

The octachlorostyrene criterion for the protection of piscivorous wildlife established by Newell et al. (1987) was exceeded by all annual means for catfish and carp in Lake St. Clair as well as in juvenile fish collected downstream of the industrial complex at Suncor and Lambton Generating Station (Table 6.52). The hexachlorobenzene criterion for the protection of piscivorous wildlife was not exceeded at any location for channel catfish, carp or juvenile fish. No guidelines for consumption of fish by humans exist for hexachlorobenzene or octachlorostyrene.

The spottail shiner monitoring program includes data from as early as 1978 in some locations. Although not conclusive, analyses of spottail shiners to 1988 indicate that concentrations of DDT, hexachlorobenzene, octachlorostyrene and PCBs have generally declined. Statistically significant reductions in fish tissue were found for PCBs and octachlorostyrene in fish collected during 1987 at the Lambton Generating Station compared to those collected in 1985 and 1986 at the same location. Total PCBs, however, have increased from 1987 to 1988 at this collection site.

Wildlife

The wildlife population of the St. Clair River AOC is diverse and abundant, particularly in the delta. Reductions in waterfowl abundance in the marshes have been documented and related mostly to physical habitat alterations (i.e., wetland loss, Section 6.2). Recent (1985 - 88) data on organic chemical contaminant burdens in wildlife and bioaccumulation are available for muskrats, turtles and waterfowl within the AOC, particularly the lower river and delta. However, there are no data on the impacts of these chemical burdens on wildlife health or population dynamics nor on health effects of those people who consume these wildlife.

The studies by The Great Lakes Institute (1987) and Glooschenko et al. (1990) indicate that PCBs, octachlorostyrene, hexachlorobenzene, pentachlorobenzene and several chlorinated pesticides were accumulating in resident muskrats and turtles and non-migratory ducks living within the AOC. Non-migratory redheads and mallards were found to have the highest concentrations of octachlorostyrene, particularly in liver tissue, as compared to other species within the AOC. The results of the studies of Weseloh and Struger (1989) indicated that herring gull eggs from colonies in the lower St. Clair River had 1.6 to 3.5 times the concentrations of hexachlorobenzene than eggs from colonies in the Detroit and Niagara Rivers and Lakes Superior, Erie and Ontario. Migratory goldeneye ducks also accumulated PCBs, DDE, octachlorostyrene, dieldrin, hexachlorobenzene and heptachlor epoxide over a three month period (December to February) while resident in the lower St. Clair River. The Weseloh and Struger (1989) studies using domestic, chemically clean ducks introduced to the St. Clair River delta indicated the bioaccumulation of octachlorostyrene, hexachlorobenzene and PCBs by up to five times within an approximately one month period (July - August).

6.4 HUMAN HEALTH EFFECTS

The routes of human exposure to environmental contaminants include inhalation of air and airborne particulates, skin contact with water or airborne particulates, the ingestion of water, food or beverages, the handling of contaminated sediments, and the inadvertent ingestion of contaminated soil (EC/DFO/HWC 1991). Residents of the Great Lakes Basin are exposed to toxic chemicals from sources both within and outside the basin. The main routes of human exposure to contaminants in the Great Lakes system is via the ingestion of fish and, to a lesser extent, drinking water (EC/DFO/HWC 1991).

There are very few data specific to human health concerns as related to chemical contamination in the St. Clair River AOC. The only specific study to date is a study of reproductive outcomes of women who used the river as a source of drinking water between 1980 and 1985. The concern in undertaking the study was based on the frequency of chemical spills to the river. This study was summarized in a recent assessment report on toxic chemicals in the Great Lakes undertaken by the federal Departments of Environment, Fisheries and Oceans and Health and Welfare (EC/DFO/HWC 1991).

The rate of stillbirths and perinatal mortality in counties using the St. Clair River as a source of drinking water was significantly less than regional and provincial rates. However, the birth weight of infants born to mothers in these counties was significantly lower than the regional or provincial rates. This study did not give an indication of major human reproductive effects due to chemical spills. A more thorough case control study has recently been completed and is being reviewed by the Ontario Ministry of Health (EC/DFO/HWC 1991).

Human health effects studies are currently planned for the Great Lakes Basin as part of the Great Lakes Health Effects Program administered by Health and Welfare Canada. The Great Lakes Health Effects Cohort Study under this program is a multi-phase project designed to investigate the relationships between human exposure to contaminants found in the Great Lakes (through the consumption of contaminated fish and wildlife) and a variety of human health endpoints. This study focuses on residents of Ontario who are not of native origin. A separate study is being developed by native communities and the Department of Health of Welfare to address similar issues for native people in Ontario.

The studies will be conducted in several phases including basic sampling of individuals purchasing sport fishing licences, followed by the identification of a cohort of households for further health effects studies. This phase will furnish essential information on the population potentially at risk through a mail-out screening questionnaire. The final phase will involve exposure assessment and health effects studies investigating the relationships between consumption of Great Lakes fish and wildlife and selected health outcomes, while controlling for the potential effects of social demographic lifestyle as well as environmental and occupational factors. Health outcomes may include immunological, developmental and reproductive endpoints. The study is being conducted in consultation with individuals, public interest groups, industry, other government agencies and scientific experts.

A recent meeting between representatives of the Assembly of First Nations and representatives of Federal and Provincial Governments provided a forum for discussions to determine steps necessary in evaluating the impacts of environmental contaminants on health of native populations in the Great Lakes Basin. The Walpole Island First Nation Band have requested their inclusion in such a study (M. Williams, Walpole First Nation Band, pers. com.).

6.5 SUMMARY AND CONCLUSIONS

Ecosystem impacts due to habitat loss and to chemical alterations within the St. Clair River Area of Concern have been documented since the 1940s. The chemical impacts have received the greatest attention due, in particular, to events such as the closure of the Lake St. Clair commercial and sport fisheries in the 1970s and the regular occurrence of large chemical spills into the river.

Studies have traditionally been compartmentalized into the individual ecosystem components including water, sediment and biota. The combined results of these individual studies reveal a remarkably consistent pattern regarding zones of impact and chemicals which may be of concern. Sources of these contaminants are discussed in Chapter 8. Chemicals which impact the river based on exceeding relevant guidelines in any of the media (b-biota, w-water and s-bottom sediments) are:

- metals - cadmium (w,s), copper (w,s), chromium (s), iron (w,s), lead (w,s), manganese (s), mercury (b,w,s), nickel (s) and zinc (w,s);
- toxic organics - PCBs (b,w,s), PAHs (s), dieldrin (w), octachlorostyrene (b,w,), hexachlorobenzene (w,s), hexachlorobutadiene (w), tetrachloroethylene (w) and carbon tetrachloride (w); and
- conventional pollutants - oil and grease (s), arsenic (s), total Kjeldahl nitrogen (s), total phosphorus (w,s), bacteria (w) and chloride (w).

Chemicals occurring in concentrations which are elevated above levels found upstream of industrial and municipal sources in the St. Clair River in at least two media but did not exceed guidelines, or for which no guidelines are available are:

- chlorinated organics - pentachlorobenzene, 1,3,5-trichlorobenzene, 1,2,3,5-tetrachlorobenzene and 1,2,4,5-tetrachlorobenzene; and

- volatile organics - chloroform.

Chemicals found in only one medium but in concentrations which are elevated either above those found upstream of municipal and industrial sources or above the area average concentrations include:

- water/suspended solids - 1,1,1-trichloroethane, methylene chloride, dibromomethane and bromodichloromethane;

- bottom sediments - tetrachloroethanes, pentachloroethanes, chlorobutenes, heptachlorostyrene, octachloronapthalene, alkanes, diphenylether, biphenyl, diethyl biphenyl, 4-ethyl biphenyl, dibenzo furans and dibenzo-p-dioxins; and

- biota - benzene, ethylbenzene, xylenes and 2,4,5-trichlorotoluene.

The ambient monitoring results summarized in this chapter suggest that industrial direct and indirect point sources are likely the primary sources of many of these chemicals. Other sources which likely contribute certain contaminants, based on the pattern of ambient contamination, include Water Pollution Control Plants, urban runoff and tributaries such as the Black River, Talfourd Creek and the Murphy Drain. Chapter 8 provides a detailed discussion of sources of individual contaminants based on source monitoring studies.

Biota, particularly benthic fauna, have been shown to be good indicators of overall ecosystem health as they integrate the effects of both water and sediment contamination. Studies of benthic community structure along with benthic chemical burdens thus provides data relating to where the contamination occurs and to what degree. Results of various studies which have been conducted between 1968 and 1986 indicate that:

1) in general, the Michigan shore of the St. Clair river has good benthic health and low concentrations of contaminants;

2) the Ontario shore including the delta channels fed by the contaminated plume (Bassett Channel, South Channel and Chenal Ecarte) have been impacted by chemicals from Ontario sources; and

3) there has been a marked improvement from 1968 through 1985 in terms of benthic community structure and reductions in chemical burdens between 1982 and 1987.

Improvements relating to community structure have been documented on the basis of a shrinking of the zone of severely impacted biota. In 1968 this zone included the entire shore of the river, in 1977 it consisted of a 21 km (13 mi) zone beginning immediately downstream of Esso Petroleum, and in 1985 it was reduced to 12 km (7.4 mi). Further reductions since 1985 have been suggested by modelling.

Improvements relating to chemical burdens in biota have also been documented. Octachlorostyrene and hexachlorobenzene have declined in mussels in the St. Clair Delta channels as well as in spottail shiners at the Lambton Generating Station. PCBs in spottail shiners declined significantly in 1987 relative to previous years at the Lambton Generating Station collection site. However, this trend did not continue into 1988.

Improvements in the chemical impacts to the ecosystem are also recorded by sediment cores collected in 1985 downstream of the Dow 1st Street Sewer complex. The upper, more recent layers in the cores show a pattern of declining concentrations of PAHs, mercury and oil and grease over time. Other sediment data collected between 1970 and 1985 confirm these findings.

Chapter 7 presents the conclusions regarding the status of beneficial uses in the St. Clair River Area of Concern.

7.0 ENVIRONMENTAL CONCERNS/USE IMPAIRMENT

7.0 ENVIRONMENTAL CONCERNS/USE IMPAIRMENT

7.1 INTRODUCTION

The objective of this chapter is to summarize the use impairments and water, sediment and biota quality problems described in Chapter 6 (Environmental Conditions). Annex 2 of the Great Lakes Water Quality Agreement of 1978, as amended in 1987, defines 'Impairment of Beneficial Use(s)' as "...a change in the chemical, physical or biological integrity of the Great Lakes System sufficient to cause any of the following:

(i) Restrictions on fish and wildlife consumption;
(ii) Tainting of fish and wildlife flavour;
(iii) Degradation of fish and wildlife populations;
(iv) Fish tumours or other deformities;
(v) Bird or animal deformities or reproduction problems;
(vi) Degradation of benthos;
(vii) Restrictions on dredging activities;
(viii) Eutrophication or undesirable algae;
(ix) Restrictions on drinking water consumption, or taste and odour problems;
(x) Beach closings;
(xi) Degradation of aesthetics;
(xii) Added costs to agriculture or industry;
(xiii) Degradation of phytoplankton and zooplankton populations; and
(xiv) Loss of fish and wildlife habitat."

Several of these use impairment categories are divided into subcategories for discussion purposes in this chapter to more clearly define the scope of the problems in the St. Clair River AOC. For example, 'restrictions on fish and wildlife consumption' is divided into 'restrictions on fish consumption' and 'restrictions on wildlife consumption'.

A determination as to whether a specific use impairment exists in the St. Clair River AOC was made using the International Joint Commission Listing/Delisting Guidelines for Great Lakes Areas of Concern in conjunction with applicable standards, guidelines and objectives where available. In the absence of standards, guidelines or objectives, impairment status is based on best professional judgement from the evidence available. The status of beneficial uses as well as exceedences of ambient standards, guidelines and objectives are summarized in Table 7.1.

7.2 USE IMPAIRMENTS

7.2.1 Restrictions on Fish and Wildlife Consumption

7.2.1.1 Restrictions on Fish Consumption

A number of fish species taken from different sections of the Ontario side of the St. Clair River Area of Concern have concentrations of mercury and/or PCBs in their flesh, which exceed Health and Welfare Canada limits, Great Lakes Water Quality Agreement Specific Objectives and Michigan Department of Public Health Trigger Levels human consumption.

Walleye greater than 55 cm (22") in length, downstream from the Blue Water Bridge, is the only species and age class for which the Ontario Ministries of Environment and Natural Resources recommend no consumption. Mercury concentration in these fish in 1985 were greater than 1.5 $\mu g/g$, exceeding both the

Table 7.1 Summary of impairments to Great Lakes Water Quality Agreement beneficial uses within the St. Clair River AOC. Impairment status is defined as impaired (I), not impaired (NI) or requires further assessment on a site specific basis[1] (A) or on a Great Lakes Basin basis[2] (B) and is based on data collected over the period 1983 through 1990[3].

GLWQA Impairment of Beneficial Use	Status of Impairment	Conditions in the St. Clair River
RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION		
Restrictions on Fish Consumption	I	Fish consumption advisories currently in effect are: Ontario - mercury: walleye, white sucker, freshwater drum and yellow perch - PCBs: carp and gizzard shad Michigan - mercury and PCBs: freshwater drum, gizzard shad and carp
Consumption of Wildlife	B	There are currently no guidelines directly applicable to the St. Clair River AOC regarding human consumption of wildlife. However concentrations of PCBs in snapping turtles as well as octachlorostyrene, hexachlorobenzene and PCBs in mallards and redheads, which are utilized by human consumers such as residents of the Walpole Island First Nations Band, highlight the need for these guidelines. The Ontario Ministry of Natural Resources has issued a warning for people to use prudence with respect to the regular consumption of turtle meat from some areas including Walpole Island due to PCBs.
TAINTING OF FISH AND WILDLIFE FLAVOUR	A	There have been anecdotal reports of tainting.
DEGRADATION OF FISH AND WILDLIFE POPULATIONS		
Dynamics of Fish Populations	NI	The fish fauna of the St. Clair River are considered diverse and well-balanced.
Body burdens of fish	B	Several contaminants including mercury, PCBs, hexachlorobenzene and octachlorostyrene have been found in adult and juvenile fish on the Ontario side of the river and in the St. Clair Delta. Effects of these chemicals on fish are not known. Research on body burdens and associated effects in fish is required for the entire Great Lakes ecosystem.
Dynamics of Wildlife Populations	A	The use of the wetlands of the St. Clair Delta by true marsh-dwelling waterfowl species declined by 79 percent (spring) and 41 percent (autumn) between 1968 and 1982 due to the loss of wetlands. Continent wide wetland loss is a factor to migrating bird survival, but this has not been assessed for wetland species in the AOC. Guidelines for the protection of fish-eating wildlife have been exceeded in juvenile fish for PCBs and in juvenile fish, carp and channel catfish for octachlorostyrene. The effects of these exceedences, if any, on wildlife populations which consume these fish are not known.
Body burdens of Wildlife	B	Contaminants such as pentachlorobenzene, hexachlorobenzene, octachlorostyrene, PCBs and DDT have been found in snapping turtles, muskrats and ducks in the St. Clair Delta. The effects of these chemicals on wildlife are not known. Research on body burdens and associated effects in wildlife is required for the entire Great Lakes ecosystem.

Table 7.1 (cont'd)

GLWQA Impairment of Beneficial Use	Status of Impairment	Conditions in the St. Clair River
FISH TUMOURS AND OTHER DEFORMITIES	A	External tumours found in fish are due to natural viral factors. Although studies on the incidence of internal tumours have been limited in the AOC, there is one observation of an early neoplastic tissue change which was observed in a caged fish. Although this finding is not statistically significant, there is a growing consensus that there is sufficient evidence to suggest liver tumours are caused by chemical factors.
BIRD OR ANIMAL DEFORMITIES OR REPRODUCTIVE PROBLEMS	I	Mouth part deformities occur in some chironomid species but no evidence of bird or other animal deformities or reproductive problems has been reported.
DEGRADATION OF BENTHOS		
Dynamics of Benthic Populations	I	Benthic community health is good on the Michigan side of the river but, as of 1985, was impaired along the Ontario shore for a distance of about 12 km (7.4 mi) beginning in the reach between the Sarnia WPCP and Dow Chemical and extending downstream past Stag Island to approximately Novacor Chemical (Canada) at Mooretown.
Body Burdens of Benthic Organisms	B	Several types of benthic organisms, including native clams, mayflies (*Hexagenia spp.*), aquatic worms (Oligochaetes) have been found to bioaccumulate various organic and inorganic chemicals. The effects of these chemicals on benthic organisms is not known. Research on body burdens and associated effects in benthic organisms is required for the entire Great Lakes ecosystem.
RESTRICTIONS ON DREDGING ACTIVITIES	I	Concentrations of copper, cadmium, chromium, iron, lead, mercury, nickel, zinc, PCBs, total phosphorus and oil and grease along the Ontario shoreline exceed OMOE guidelines for the open water disposal of dredged sediments and all but PCBs, cadmium and nickel are classified as heavily polluted by the U.S. EPA interim guidelines for the disposal of Great Lakes harbor sediments. Most exceedences occur along the Sarnia industrial waterfront, as far downstream as the Lambton Generating Station, and the mouths of Talfourd Creek, Baby Creek and the Murphy Drain. Confined disposal has been required in some instances due to the presence of HCB. Concentrations of total Kjeldahl nitrogen, oil and grease, arsenic, copper, chromium, iron, lead and manganese from the Michigan shore are considered moderately or heavily polluted by U.S. EPA guidelines and exceed OMOE disposal guidelines. There are currently no restrictions on dredging or disposal of dredged material from U.S. waters of the St. Clair River due to the presence of contaminants.
EUTROPHICATION OR UNDESIRABLE ALGAE	NI	The waters of the St. Clair River are mesotrophic and algae do not occur at nuisance levels.

Table 7.1 (cont'd)

GLWQA Impairment of Beneficial Use	Status of Impairment	Conditions in the St. Clair River
RESTRICTIONS ON DRINKING WATER CONSUMPTION OR TASTE AND ODOUR PROBLEMS		
Consumption	I	Periodic closing of Water Filtration/Treatment Plants occur in both Michigan and Ontario as a result of chemical spills at upstream locations.
Taste and Odour Problems	I	The Health and Welfare Canada taste and odour aesthetic objective for ethylbenzene was exceeded at the Wallaceburg Water Treatment Plant during start-up following a spill in October 1990. Closures of the Wallaceburg WTP intakes based on level II responses are based on factors including taste and odour concerns.
BEACH CLOSINGS	I	There have been no beach closings in Michigan although all areas downstream of Michigan CSOs are identified as impaired areas due to the periodic discharge of inadequately treated sewage. In Ontario, five beaches were closed as recently as the summer of 1990 for up to two months duration due to coliform bacteria levels which exceeded both Ontario and Michigan standards.
DEGRADATION OF AESTHETICS	I	Floating scums, oil slicks, spills and odours have been periodically reported.
ADDED COST TO AGRICULTURE OR INDUSTRY	I	Food processing industries in Ontario and a salt processing facility in Michigan have had to temporarily shut down their intakes due to upstream spills. Costs have also been incurred for proper disposal of contaminated sediment removed from the river for construction or other purposes.
DEGRADATION OF PHYTOPLANKTON AND ZOOPLANKTON POPULATIONS	NI	Phytoplankton and zooplankton species in the river are typical of those in southern Lake Huron.
LOSS OF FISH AND WILDLIFE HABITAT	I	Habitat has been lost due to filling, draining, dredging and bulkheading for industrial (Sarnia), urban, agricultural and navigational uses. Significant losses of wetlands have occurred particularly in the delta region of the AOC. Fish and wildlife management goals are needed to help further determine the degree of impairment and guide rehabilitation strategies.

Table 7.1 (cont'd)

Exceedences of Water Quality Objectives, Guidelines or Standards Within the St. Clair River AOC	
Objectives/Standards	**Exceedences**
GLWQA Annex 1 Specific Objectives and Ontario PWQO for the Protection of Aquatic Life	Iron - Ontario, downstream of Sarnia and Chenal Ecarté Zinc - Walpole Island WTP intake Copper - Lambton and Walpole Island WTP intakes Cadmium - near Dow and Suncor outfalls Hexachlorobenzene (PWQO) - Ontario, Cole Drain to Stag Island; mouth of Talfourd Creek
Provincial Water Quality Guideline	Phosphorus - Wallaceburg Water Treatment Plant intake
Provincial Swimming and Bathing Use of Water	Bacteria - five beaches along Ontario shore closed due to exceedences during 1990
Michigan WQS, Rule 51 Michigan WQS, Rule 57(2), January 1991	Chloride - adjacent to Sarnia industrial waterfront Mercury - offshore and immediately downstream of Sarnia industrial area; Chenal Ecarté; and in raw water at Lambton, Walpole and Wallaceburg treatment plant intakes Zinc - Walpole Island WTP intake Copper - Lambton and Walpole Island WTP intakes Cadmium - near Dow and Suncor outfalls Lead - downstream of the mouth of the Black River Total PCBs - throughout river in Michigan and Ontario Dieldrin - throughout river in Michigan and Ontario Carbon Tetrachloride - offshore of Dow Chemical Hexachlorobenzene - Ontario, Cole Drain to Stag Island; mouths of Talfourd and Bowens Creeks; Chenal Ecarté Tetrachloroethylene - Ontario, offshore of Dow Chemical
Michigan WQS, Rule 62 (total body contact)	Bacteriav - five beaches along Ontario shore CSOs - all areas downstream of Michigan Combined Sewer Overflows.

[1] The Impairment Status 'requires assessment' in the St. Clair River AOC.
[2] The Impairment Status 'requires assessment' on a Great Lakes Basin basis.
[3] The date of data collection as well as the location and magnitude of the impairment is summarized in Table 6.23 (water quality), 6.30 (sediment) and 6.52 (biota).

OMOE fish consumption guidelines and the Heath and Welfare Canada guideline of 0.5 μg/g. Carp adjacent to Ethyl Corporation and gizzard shad adjacent to Stag Island have PCB concentrations in excess of the 2.0 μg/g Health and Welfare Canada limits and Michigan Department of Public Health Trigger Levels as well as the GLWQA Specific Objective (1.0 μg/g). Carp collected near Algonac, Michigan during July 1986 were contained an average concentration of 2.214 μg/g total PCBs which exceeded all three guidelines. In addition, the Michigan Department of Public Health has recommended restricted consumption of gizzard shad over 25 cm (10") in length and freshwater drum greater than 30.5 cm (12") in length throughout the St. Clair River based on mercury and PCBs. It also recommended no consumption of carp taken from the river.

This beneficial use is impaired.

7.2.1.2 Consumption of Wildlife

There are no formal advisories currently in place for the consumption of wildlife by humans. The Ontario Ministry of Natural Resources has issued a statement suggesting people should use prudence with respect to the regular consumption of adult turtle meat from some areas. The statement was based on a monitoring program which indicated that snapping turtle meat from four areas sampled in Ontario (including Walpole Island) had elevated concentrations of PCBs. The levels in turtle meat from Walpole Island were between 0.06 and 0.45 μg/g. Specific guidelines, standards or objectives for the consumption of wildlife by humans have not yet been developed.

Guidelines for the protection of humans who consume wildlife are urgently required. Notwithstanding, that this is a general problem in the Great Lakes Basin, it is recognized that a special situation exists in the St. Clair River with respect to octachlorostyrene. The need for guidelines is particularly important with regard to sport hunting and the use of mallards and redheads (octachlorostyrene, hexachlorobenzene and PCBs) and turtles (PCBs) as dietary components for residents of the Walpole Island Reserve.

The status of this use cannot be determined due to the absence of applicable guidelines. Additional research in this regard is required on a basin wide basis.

7.2.2 Tainting of Fish and Wildlife Flavour

No recent reports of tainted fish or wildlife are on record, however, some anecdotal incidents of tainting have been verbally provided by residents of Walpole Island.

This beneficial use requires assessment in the St. Clair River AOC.

7.2.3 Degradation of Fish and Wildlife Populations

7.2.3.1 Dynamics of Fish Populations

The fish community of the St. Clair River is diverse consisting of almost 100 sport and forage species. While the native cold-water fishery has disappeared, particularly the large runs of lake trout, lake whitefish and lake herring which entered the river to spawn, its ecological niche has been filled by a variety of exotic species including rainbow trout, brown trout, chinook salmon, coho salmon and rainbow smelt.

Due to the changes in the fish community structure that have taken place over time, it has been suggested that some degradation of fish populations has occurred. However, a return to an historic fish community structure is not possible or realistic. Improved or increased fish habitat may result in increased biomass and community diversity and thus, an even further enhanced fishery. Draft fish community goals and objectives for Lake St. Clair and connecting waters have been developed jointly by the Michigan Department of Natural

Resources and the Ontario Ministry of Natural Resources. The goals and objectives support the current fish community structure with walleye as the top predator species, based on a foundation of stable, self-sustaining stocks.

A large and diverse forage base is available for the coldwater, coolwater and warmwater piscivores. The fish fauna appears to fully utilize all energy sources of the ecosystem - benthos, zooplankton, algae and macrophytes. In general, the fish fauna of the St. Clair River are considered diverse and well-balanced.

This beneficial use is not impaired.

7.2.3.2 Body Burdens in Fish

Mercury, lead, PCBs, carbon tetrachloride, tetrachloroethylene, hexachlorobenzene, octachlorostyrene, PAHs, hexachloroethane, hexachlorobutadiene and other contaminants have been found in sport fish or shiners exposed to discharges on the Ontario side of the St. Clair River (Section 6.3.3). Additionally, concentrations of some persistent pollutants such as mercury, hexachlorobenzene, octachlorostyrene and PAHs are higher in some sampled organisms than in water or sediment, reflecting the tendency of these contaminants to bioaccumulate. The effects of individual or multiple contaminant body burdens have not been determined.

General research on body burdens and associated effects in fish in the Great Lakes is needed on a basin wide basin.

7.2.3.3 Dynamics of Wildlife Populations

St. Clair River waterfowl populations are low, owing to physical and biological constraints of the river environment. The delta, however, is heavily utilized by waterfowl. This use peaks during the autumn and spring when the area becomes one of the most important waterfowl staging areas in Ontario. The peak numbers of waterfowl using the St. Clair marshes during the periods of spring and fall migration did not change between 1968 and 1982. However, use of the wetlands by true marsh-dwelling species declined by 79 percent (spring surveys) and 41 percent (autumn surveys) between 1968 and 1982. McCullough (1985) attributed these losses to declines in the area of the wetlands due to drainage from agricultural purposes as well as from cottage and marina developments. The significance and exact cause of the changes noted by McCullough (1985) have not been conclusively determined, however, activities and developments related to agricultural and navigational uses as well as external changes in North American waterfowl populations have contributed to the decline. Continent wide wetland loss is a factor to migratory bird survival, but this has not been assessed for wetlands species in the AOC.

The Area of Concern, particularly the St. Clair delta, provides habitat for amphibians and reptiles, birds other than waterfowl, and mammals including a number of rare species. Population changes in these other wildlife groups have not been assessed.

The possibility exists that contaminant concentrations are affecting wildlife populations. A guideline of 0.02 $\mu g/g$ for octachlorostyrene was established by New York State for the protection of fish-eating wildlife. The guideline was designed for the protection of the individual from liver damage (Newell et al. 1987). The concentrations of octachlorostyrene in young-of-the-year shiners along the Ontario shore from the industrialized region downstream to the Lambton Generating Station and in the South Channel exceeded 0.02 $\mu g/g$. This guideline was also exceeded for carp and channel catfish. PCB concentrations in fish flesh at the Lambton Generating site exceeded the Great Lakes Water Quality Objective of 0.1 $\mu g/g$ for the protection of fish-eating birds. This guideline was also exceeded in juvenile fish. The impact of these guideline exceedences on wildlife populations has not been quantified. Impacts to wildlife in the St. Clair River AOC as a result of the consumption of fish that exceed these guidelines have not been documented.

This beneficial use requires assessment in the St. Clair River AOC.

7.2.3.4 Body burdens of Wildlife

Contaminant burdens of some organic compounds have been measured in adult turtles, muskrats and ducks on Walpole Island. Non-migratory ducks (mallards and redheads) generally contain higher concentrations of octachlorostyrene, hexachlorobenzene, and PCBs than did migrating individuals. The impact of these and other chemicals to the health and reproductive capacity of wildlife is not known. There are currently no guidelines based on concentrations of contaminants in wildlife to protect predator wildlife.

The effects of individual and multiple, contaminant body burdens have not been determined. General research on body burdens and associated effects in wildlife in the Great Lakes Basin is needed.

7.2.4 Fish Tumours and Other Deformities

Existing data, concerning external tumours or skin lesions (i.e., lymphocystis and dermal sarcoma) for walleye from the Area of Concern, do not suggest they are linked to anthropogenic factors, but rather are caused by natural factors. Also, there is no evidence linking the presence of these diseases to problems of human health or with fish populations. There are, however, few data concerning internal tumours other than one observation of early neoplastic tissue changes observed in one fish held in a cage downstream of the Sarnia industrial complex. Although this finding is not statistically significant, there is a growing consensus that there is sufficient evidence to suggest liver tumours are caused by chemical factors. Further assessment is required before the condition of this beneficial use can be judged.

This beneficial use requires further assessment in the St. Clair River AOC.

7.2.5 Bird or Animal Deformities or Reproductive Problems

An abnormally high number of mouth-part deformities are recorded in some chironomid species along the Ontario side of the river below the Sarnia industrial complex and at Courtright. No other evidence of reproductive problems or deformities have been noted in the wildlife populations in the Area of Concern. However, studies specifically examining this issue have not been conducted.

This beneficial use is impaired.

7.2.6 Degradation of Benthos

7.2.6.1 Dynamics of Benthic Populations

Benthic community health along the Michigan shore is good. On the Ontario side, data up to and including 1985 reveal that the benthic community begins to be impacted about 7 km (4.3 mi) downstream from the head of the river, near Sarnia's industrial complex. The zone of benthic impairment extended for a distance of about 12 km (7.4 mi) beginning in the reach between the Sarnia WPCP and Dow Chemical and extending downstream past Stag Island to approximately Novacor Chemical (Canada) at Mooretown. The most severely degraded portion occured along an approximately 1 km (0.6 mi) reach of the river beginning near the southern edge of Polysar and continuing offshore of Dow Chemical. Downstream of Stag Island, the benthic community gradually improved, reaching a 'good' condition approximately 20 km (12.4 mi) from the head of the river.

Severely degraded benthic communities as defined in Chapter 6 by organisms common to 'community 7' (Section 6.3.3) appear to be confined to the Sarnia industrial waterfront and a few kilometres downstream.

In this region, conditions were unsuitable for a number of pollution-intolerant benthic species including indicator organisms, such as, mayfly nymphs and freshwater scud.

Bioassay studies undertaken in 1986 identified sediments downstream of the Cole Drain as being acutely lethal to minnows (*Pimphales promelas*) and mayflies (*Hexagenia limbata*).

This beneficial use is impaired.

7.2.6.2 Body burdens of Benthic Organisms

Concentrations of hexachlorobenzene, octachlorostyrene, hexachloroethane and hexachlorobutadiene were found at elevated levels in caged mussels exposed to Ontario shoreline discharges during 1986 relative to those in upstream locations. Uptake levels were greatest between Dow Chemical and Suncor Inc. The rate of uptake decreased rapidly downstream of this area. Several volatile organics including benzene, chloroform, ethylbenzene and xylene were also found in caged mussels within the heavily impacted area. In caging studies conducted in 1982, hexachlorobenzene, octachlorostyrene, hexachlorobutadiene, 2,3,6-trichlorotoluene and α-BHC were the most frequently identified contaminants found in mussels following three weeks of exposure. PCBs were detected in caged mussels held immediately below Sarnia, however, concentrations were low.

Contaminant body burdens have been measured in some St. Clair River macrozoobenthos. Concentrations of heavy metals (copper, zinc, lead, cadmium, iron and manganese) have been measured in oligochaetes (a gatherer) near Stag Island in 1983 (Section 6.3.3). Octachlorostyrene and hexachlorobenzene have been found to bioaccumulate in the mayfly *Hexagenia spp.* (collector-gatherer organisms) from sediments in 1986. Contaminant concentrations increased from upstream of the Sarnia industrial waterfront, reaching highest values downstream of Polysar and Dow. Introduced, caged mussels (a filter feeder) showed similar patterns.

The effects of individual and multiple, contaminant body burdens have not been determined. General research on body burdens and associated effects in benthos in the Great Lakes Basin is needed.

7.2.7 Restrictions on Dredging Activities

Concentrations of copper, cadmium, iron, lead, mercury, nickel, zinc, PCBs, total phosphorus, and oil and grease, along the Ontario shoreline exceed OMOE Guidelines for the Open Water Disposal of Dredged Sediments, and all but PCBs, cadmium and nickel are classified as heavily polluted by the U.S. EPA Interim Guidelines for the Disposal of Great Lakes Harbour Sediments. The most exceedences occur along the Lambton Generating Station, and the mouths of Talfourd Creek, Baby Creek and the Murphy Drain. On a case by case basis, examples of requirements for refused disposal have occurred due to the presence of HCB in Ontario Sediment.

Since sediment quality concerns have been raised in the St. Clair River, it has become the practice to have industrial clean-out projects for intakes and forebays in and downstream of the Chemical Valley addressed as discrete projects. The practice includes containment of the sediment, and analysis for parameters listed in the dredging guideline as well as HCB. The sediment is disposed of according to the analytical results, guidelines and/or Regulation 309 and in some instances has required confined disposal. HCB has been identified as an indicator compound of a contamination, and eliminates the need for a wider scan of compounds. (L. Burgess pers com)

In the vicinity of and downstream from the Sarnia industrial complex, sediments are also contaminated to varying degrees with hexachlorobenzene, octachlorostyrene, hexachlorobutadiene, hexachloroethane, diphenylether, biphenyl and several other organic chemicals (Section 6.3.2). Although guidelines are not presently available for these compounds, the proposed Ontario sediment quality guideline for PAHs was exceeded at the lowest effect level and for hexachlorobenzene was exceeded at the lowest effect and severe effect levels. The PAH guideline was exceeded at Sarnia Bay, along the Sarnia industrial waterfront and at one site on the Michigan side upstream of the CN Tunnel. Hexachlorobenzene exceeds the sediment quality guideline on the Ontario side from the Sarnia Water Pollution Control Plant downstream to the Lambton Generating Station. The Provincial Sediment Quality Guidelines have been developed to provide guidance during decision making in relation to sediment issues, ranging from preventative or remedial action. They were developed for use in evaluating sediments throughout Ontario, in order to replace the Open Water Disposal Guidelines currently used for sediment evaluation.

Sediments on the Michigan side of the river are generally much less polluted than those on the Ontario side. Concentrations of oil and grease, total Kjeldahl nitrogen, arsenic, chromium, copper, iron, lead and nickel occasionally exceeded the Ontario open water disposal of dredged material guidelines. The heavily polluted category of the U.S. EPA interim guidelines for the disposal of harbor sediments was exceeded by concentrations of oil and grease, total Kjeldahl nitrogen, arsenic, copper, iron, lead and manganese from Michigan locations. The highest concentrations of chromium and nickel found in sediments along the Michigan shore were classified as moderately polluted. The most heavily polluted sediments were found in the river adjacent or immediately downstream of Port Huron, Marine City and Algonac as well as at the mouths of the Black and Pine Rivers. The locations from which the Michigan samples were collected are not currently dredged. If a proposal were made to dredge these sediments, additional monitoring would be required to determine whether restrictions on either the dredging activity or disposal of the sediment would be necessary. There are currently no restrictions on dredging or disposal of dredged material from U.S. waters of the St. Clair River due to the presence of contaminants.

This beneficial use is impaired.

7.2.8 Eutrophication or Undesirable Algae

Lake Huron is the source of most of the St. Clair River's phytoplankton stocks, with diatoms, chrysophytes and chlorophytes dominating. The waters of lower Lake Huron are slightly mesotrophic on the basis of phytoplankton density. While little work has been undertaken on the smaller (nanno- and micro-) phytoplankton of the river, the larger phytoplankton species are typical of oligotrophic waters. The filamentous alga, *Cladophora spp.* and other filamentous algae are not found at nuisance levels.

This beneficial use is not impaired.

7.2.9 Restrictions on Drinking Water Consumption or Taste and Odour Problems

7.2.9.1 Consumption

On both the Michigan and Ontario sides of the river, treated water is not impaired for human consumption. However, there are occasions when water treatment plants are shut down as a precautionary measure following upstream spills. Closure of water treatment plant intakes ensures the quality of drinking water is not impaired, however, the supply of water is impaired.

Numerous closures have also been reported for the Wallaceburg and Walpole Island Water Treatment Plants in Ontario and the City of Marysville, East China Township, Marine City, Algonac and Old Club Water Filtration Plants in Michigan (Section 6.3.1.17). At times the precaution is warranted, such as during the March 1989 ICI spill of Selexol and the October 1990 and May 1991 spills of ethylbenzene from Dow, both of which resulted in the closure of the Wallaceburg Treatment Plant.

Carbon filtration has been added to the Wallaceburg and Walpole Island Water Treatment Plants for added treatment of organic contaminants associated with spills. Water filtration plants in Michigan have been advised to provide for the addition of activated carbon treatment. The addition of carbon filtration involves additional costs. The periodic closure of water treatment/filtration plants in both Ontario and Michigan, due to upstream spills, also increases the costs to municipalities. Additional costs have been incurred in Ontario due to provision of bottled water during water treatment filtration plant closures.

This beneficial use is impaired.

7.2.9.2 Taste and Odour Problems

Elevated total heterotrophic bacterial populations occurring in the river and in river sediments may adversely affect municipal drinking water supplies by contributing to taste and odour problems (OMOE 1990). The October 1990 spill of ethylbenzene from Dow exceeded the Health and Welfare Canada tentative aesthetic objective for taste and odour by almost 20 times at the Wallaceburg intake. Concentrations within the Wallaceburg supply system slightly exceeded the objective during start-up, resulting in the continued closure of food processors. The Wallaceburg Water Treatment Plant closures during chemical spills are associated with taste and odour problems (level II response). Records at this facility indicate three level II responses during each of 1989 and 1990.

This use is impaired.

7.2.10 Beach Closings

Swimming advisories lasting up to two months in duration were placed on at least five bathing areas on the Ontario side of the St. Clair River during 1990 due to bacterial contamination in excess of the PWQO of 100 fecal coliforms/100 mL. There are no reports of beach closings in Michigan. Geometric mean fecal coliform bacterial counts at eight Michigan beaches during 1990 were below the Michigan WQS, Rule 62 value of 200 organisms/100 mL. However, all areas downstream of Michigan Combined Sewer Overflows are identified as impaired areas due to the periodic discharge of inadequately treated sewage.

This beneficial use is impaired.

7.2.11 Degradation of Aesthetics

On occasion, floating scums, slicks, periodic spills, and objectionable odours, are reported, mainly adjacent to and downstream from Sarnia on the Ontario side.

This beneficial use is impaired.

7.2.12 Added Cost to Agriculture and Industry

When additional costs are required to treat water prior to use for agricultural, municipal or industrial purposes, this use category is considered to be impaired.

In Michigan, Akzo Salt (formerly Diamond Crystal Salt), a food grade processor of salt, temporarily shut down its water intake from the St. Clair River due to a spill in February of 1989 resulting in additional costs to the company. On the Ontario side, food processors in Wallaceburg temporarily shut down following the October 1990 ethylbenzene spill from Dow. The plants remained closed until the water supply system could be flushed due to concentrations of ethylbenzene in excess of the Health and Welfare Canada tentative aesthetic objective for taste and odour.

In addition, there are numerous unquantifiable costs related to activities such as the confined disposal of contaminated sediments dredged for marine construction purposes, and for the extension of the drinking water pipeline from the Lambton WTP and associated plant capacity upgrading.

This beneficial use is impaired.

7.2.13 Degradation of Phytoplankton and Zooplankton Populations

Phytoplankton and zooplankton populations reflect the oligotrophic to mesotrophic conditions of lower Lake Huron.

This beneficial use in not impaired.

7.2.14 Loss of Fish and Wildlife Habitat

Fish and wildlife habitat on both sides of the St. Clair River have been altered considerably over the last century due to industrialization, urban development, diking, drainage for agricultural purposes, and the development of navigational channels. The loss of wetlands from Lake St. Clair, including portions of the AOC lying within the delta, has been well documented and include at least 5,252 ha (12,972 acres) in Michigan and 1,064 ha (2,628 acres) in Ontario. Most of this occurred in the area of the delta. Much of the original shoreline has been filled and bulkheaded, eliminating and/or altering the littoral zone (shallow water areas) which resulted in major losses of fish and wildlife habitat. Present day development pressures continue to threaten fish and wildlife habitat.

Impacts related to the loss of habitat as a consequence of water and sediment quality issues have not been well documented. Exceedences of guidelines such as the sediment quality guideline and water quality guidelines for the protection of aquatic life are common along the Ontario shore downstream of the Cole Drain and in the area of the delta.

With regard to physical losses of habitat, however, it is clear that wetlands and littoral areas in the Area of Concern provide important habitat for fish and wildlife species/communities and should be protected. Draft fish community goals and objectives for Lake St. Clair and connecting waters have been developed jointly by the Michigan Department of Natural Resources and the Ontario Ministry of Natural Resources. Among other things, they emphasize the achievement of no net loss of the productive capacity of fish habitats and the restoration of habitats wherever possible. Wildlife community goals specific to the AOC have not yet been drafted, however, Ontario based strategic planning documents provide a broad level of direction for wildlife management. These documents emphasize, *inter alia*, the need to achieve no net loss of remaining wildlife habitat and, where possible, to rehabilitate degraded habitat.

This beneficial use is impaired due to physical habitat losses. Fish and wildlife management goals are needed to help further determine the degree of impairment and guide rehabilitation strategies. Habitat losses related to chemical impacts may benefit from further study, however, by addressing other use impairments and achieving water quality standards, it is likely that fish and wildlife habitat will improve.

8.0 SOURCES

8.0 SOURCES

8.1 INTRODUCTION

The sources of chemicals which impact on water quality, sediment and biota in the St. Clair River Area of Concern include point sources and nonpoint sources. Point sources refer to the discharge of effluent streams through man-made pipes and sewers. These include both municipal sewage treatment facilities and industrial process or waste streams. Industries or municipalities that discharge to tributaries are considered as indirect point sources. Nonpoint sources are diffuse inputs which reach the river from multiple points of origin including natural and man-made delivery mechanisms. These may include atmospheric deposition, intermittent urban runoff, rural land runoff, navigation, groundwater migration (including contributions from waste disposal sites) and release from bottom sediments.

Several contaminants of concern for the St. Clair River RAP were identified in Chapter 6 on the basis of exceedences of guidelines established for the concentration of chemicals in sediment, biota and/or water. These chemicals are listed below and the media for which they exceeded guidelines are also indicated (b-biota; w-water; s-sediment):

Metals	Conventional Pollutants	Organic Contaminants
cadmium (w,s)	oil and grease (s)	octachlorostyrene (b,w)
copper (w,s)	total Kjeldahl nitrogen (s)	hexachlorobenzene (w,s)
chromium (s)	total phosphorus (w,s)	hexachlorobutadiene (w)
iron (w,s)	arsenic (s)	tetrachloroethylene (w)
lead (w,s)	bacteria (w)	carbon tetrachloride (w)
manganese (s)	chloride (w)	dieldrin (w)
mercury (b,w,s)		PCBs (b,w,s)
nickel (s)		PAHs (s)
zinc (w,s)		

At least some loadings data are available for most of these parameters. Chromium and hexachlorobutadiene loadings data were not available at the time of writing. Fecal coliform bacteria data are not directly comparable to that for the other parameters as bacteria are measured as densities of organisms (i.e., number of organisms per unit volume), not as loadings (i.e., weight per unit time). Bacteria data are generally not included in this chapter. Primary sources are known to be urban and rural runoff, combined sewer overflows and municipal Wastewater Treatment Plants.

As part of the MISA program, the Ontario Ministry of the Environment identified a list of contaminants of greatest concern based on combined exposure and effects concerns. This list, and the rationale of its development, are contained in the report entitled; "Effluent Monitoring Priority Pollutants List" (EMPPL, OMOE 1987a).

The EMPPL utilizes a chemical hazard assessment methodology based on a chemical's environmental persistence, potential to bioaccumulate, acute and sublethal toxicity to biological organisms including humans, and potential to exist in effluents discharged to surface waters. The list is comprised of those chemicals that have been detected or are potentially present in Ontario municipal and industrial effluents and pose a hazard to the receiving environment. Hazard assessment data obtained from the primary literature and used in the development of the EMPPL, was compiled into the Chemical Evaluation Search and Retrieval System (CESARS) data base jointly prepared by the Ontario Ministry of the Environment and the Michigan Department of Natural Resources.

Based on this list, several additional parameters known to occur in the St. Clair River have been identified as being of interest with regard to source identification. These are:

Benzene	Pentachlorobenzene
Toluene	Chlorophenols
Xylene	1,1- and 1,2-Dichloroethane
Carbon Tetrachloride	Trichloroethylene
Hexachloroethane	1,1,1- and 1,1,2-Trichloroethane
2,4,5-Trichlorotoluene	

Pentachlorobenzene and chlorophenols belong to the general class of chlorinated organics (higher molecular weight chlorinated aromatic organics) whereas the remainder are volatile organics (lower molecular weight volatile organics). Tetrachloroethylene, which is included in the list of parameters exceeding guidelines, is also classed as a volatile organic. Of those parameters in the EMPPL list, loadings data are most complete for chlorophenols (as total phenols).

Ammonia-nitrogen, cyanide and suspended solids are also considered important even though they do not exceed guidelines nor are they listed as part of the EMPPL. This is due to the fact that they are ubiquitous in the Environment, and in some incidences may be responsible for effects other than those for which chemicals were evaluated to be considered for inclusion on the EMPPL. Ammonia-nitrogen has exceeded guidelines for water quality in the past, however, there are little or no recent data for this parameter. Suspended solids adsorb chemicals and are thus important with regard to the delivery and transport of various chemicals to and through the AOC. Loadings of these three parameters are monitored in the effluent of numerous point sources.

Chapter 8 is divided into two major sections, point and nonpoint sources. The point source section is further subdivided into municipal and industrial point sources which are described on an individual basis for Ontario and Michigan. The nonpoint source section has seven sections of which two are dominant. These are waste disposal sites and landfills, and spills. For both Ontario and Michigan, waste disposal sites and landfills are described individually. The other parts of the nonpoint source section are described separately for Ontario and Michigan if data were available. The most recent loadings data[1] for parameters measured from point and nonpoint sources, except for spills, is tabulated in the summary section (Section 8.4) in order to determine total and relative average daily loadings of contaminants to the St. Clair River. This summary table is reproduced below as Table 8.1 to assist the reader in comparing among sources and parameters. It should be noted that this table is not a complete loading summary as all sources identified have not been analyzed for all parameters.

It should be noted that the method of computing loads is not the same for all tables reported in this chapter. In some cases, geometric means, medians and mean concentrations are used with a variety of flows in order to estimate loadings. These calculations will produce similar results if the data are not highly skewed, however, this may not be the case with some organic contaminants that tend to be log-normally distributed. The impact of some contaminants may depend on the infrequent but very large loads (e.g., the highest 10 percent of the load frequency distribution curve) can contribute as much as all the other loads combined.

[1] Loadings data in this chapter are presented only in metric units (kilograms of pollutant per day) as the size and complexity of the numerous tables do not permit presentation in imperial units as well. Multiplying kg/day by a factor of 2.205 will give the loading values in pounds per day.

Table 8.1 Summary of major point and nonpoint source loadings (kg/d) to the St. Clair River 1986-1989 (also presented as Table 8.49).

Major Sources	Oil& Grease	Total Phosphorus	Ammonia Nitrogen	Suspended Solids	BOD5	Chloride	Copper	Iron	Lead	Mercury
PETROLEUM SECTOR										
Esso Petroleum	30.6	20.8	7.02	0	-	-	-	-	-	-
Shell Canada	8.15	9.9[b]	16.57	210.0	-	4,910[b]	-	-	-	-
Novacor Chemicals, Corunna	1.25	-	5.17	21.7	-	-	-	-	-	-
Suncor	45.6	-	17.45	219.0	-	-	-	-	-	-
ORGANIC CHEMICALS SECTOR										
Dow Chemical	285[b]	-	-	2413	-	283,820	6.24[b]	85.5	0.51	0.0163
Polysar/Novacor	3.68	15.8[b]	12.21	0	-	19,900	0.93[b]	-	0.08	0.0004
Ethyl Canada	-	-	-	-	-	29,800[c]	0.44[b]	19.1[b]	8.71[c]	0.0057[b]
DuPont Canada	-	-	-	-	-	-	0.45[b]	-	-	0.0019[b]
Esso Chemical	7.37	-	11.5	154.0	-	-	-	-	-	-
Novacor Chemicals, Mooretown	-	0.50[c]	-	21.9[c]	-	-	-	-	-	-
INORGANIC CHEMICALS SECTOR										
ICI Nitrogen Products	128[b]	3.91[c]	226.0[c]	4986[c]	-	-	-	209[b]	-	-
Fiberglas Canada	-	-	-	-	-	-	-	-	-	-
Lambton Generating Station	-	-	-	773	-	-	-	-	-	-
Cole Drain	1300[b]	-	-	3060.5[b]	-	11,400[b]	1.32[b]	23.5[b]	0.385	0.0022
ONTARIO MUNICIPAL SECTOR										
Pt. Edward WPCP	-	4.06	-	67.1	110.60	-	-	14.4[b]	-	-
Sarnia WPCP	244[b]	28.51	958	1299.7	2,127.71	6,200[b]	1.0	137.0[b]	4.5	0.005
Corunna WPCP	-	0.78	-	15.68	7.45	-	-	-	-	-
Courtright WPCP	-	0.26	-	8.26	3.84	-	-	-	-	-
Sombra Lagoon	-	0.02	-	15.56	0.42	-	-	-	-	-
Port Lambton Lagoon	-	0.08	-	17.82	0.67	-	-	-	-	-

Table 8.1 (Cont'd)

Major Sources	Oil& Grease	Total Phosphorus	Ammonia Nitrogen	Suspended Solids	BOD5	Chloride	Copper	Iron	Lead	Mercury
MICHIGAN MUNICIPAL SECTOR										
Port Huron WWTP	251[b]	25.0	-	250	-	-	0.64	-	-	-
Marysville WWTP	-	6.17	-	76	206	-	-	-	-	-
St. Clair WWTP	-	2.72	15.73	48.5	39.8	-	-	7.8[b]	0.23	-
Marine City WWTP	-	1.81	30.6[b]	34	82.1	-	-	12.4[b]	-	-
St. Clair-Algonac WWTP	-	2.91	181.0[b]	83.2	95.9	-	-	22.1[b]	-	ND
MICHIGAN INDUSTRIAL SECTOR										
James River KVP	-	-	-	209	250	-	-	-	-	-
E.B. Eddy Paper	294[b]	1.92	-	449	811	-	-	-	-	-
Akzo Salt	-	-	-	34	-	31,234	-	-	-	-
Detroit-Edison/St. Clair	76.5	-	-	393.3	-	-	-	-	-	-
Detroit-Edison/Belle	0.31	-	-	1.01	-	-	-	-	-	-
Detroit-Edison/Marysville	0.42	-	-	4.35	-	-	-	-	-	-
TOTAL POINT SOURCE LOADS	2,675.88	125.15	1,481.25	14,320.18	3,735.49	387,264	11.02	530.8	14.42	0.0315
TOTAL NONPOINT SOURCE LOADINGS	129.3-201.1	6.03-13.97	20.0-51.0	-	-	3,223-6,474	1.26	118-133	5.6	0.0023-0.004
TOTAL LOADINGS TO ST. CLAIR RIVER	2,805.18-2,876.98	131.18-139.12	1501.25-1532.25	14,320.18	3,735.49	390,487-393,738	12.28	648.8-663.8	20.02	0.0338-0.0355
TOTAL LOADINGS UGLCCS (1988)	3299-3371	95.9-103.9	1690-1721	9,400	7700	359,233-362,474	13.06	700-715	34.6	0.047-0.048

Table 8.1 (Cont'd)

Major Sources	Zinc	Nickel	Cadmium	Cobalt	Cyanide	Phenols	Volatiles	PAHs	PCBs	HCB	OCS
PETROLEUM SECTOR											
Esso Petroleum	0.49[c]	0.287[b]	-	-	-	0.13	0.75[c]	ND[b]	ND	-	-
Shell Canada	2.06[c]	0.519[b]	-	-	0.144[b]	0.099	4.04[c]	ND[b]	ND	-	-
Novacor Chemicals,Corunna	2.81[c]	-	-	-	-	0.023	0.00[c]	ND[b]	ND	-	-
Suncor	0.46[c]	-	-	-	-	0.188	0.23[c]	0.020[b]	ND	-	-
ORGANIC CHEMICALS SECTOR											
Dow Chemical	9.2[b]	0.644[b]	0.0041	-	ND[b]	1.3	31.41	ND[b]	0.0032[b]	0.012	0.0041
Polysar/Novacor	-	0.657[b]	0.0033	0.67[b]	0.16[b]	0.4	124.0[b]	0.163	ND[b]	ND	0.0002
Ethyl Canada	-	-	-	-	ND[b]	-	43.2[b]	0.045	ND[b]	-	-
DuPont Canada	-	0.385[b]	-	-	-	0.09	-	ND[b]	ND[b]	-	-
Esso Chemical	1.7[b]	-	-	-	-	0.032	-	ND[b]	ND[b]	-	-
Novacor Chemicals, Mooretown	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
INORGANIC CHEMICALS SECTOR											
ICI Nitrogen Products	2.4[b]	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Fiberglas Canada	-	-	-	-	-	0.015[c]	-	ND[b]	ND[b]	-	-
Lambton Generating Station	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Cole Drain	2.0[b]	0.243[b]	0.0465	-	0.54[b]	0.88[b]	1.61	0.172[b]	ND[b]	0.0088	0.0092
ONTARIO MUNICIPAL SECTOR											
Pt. Edward WPCP	-	-	-	-	-	1.69[b]	-	ND[b]	ND[b]	-	-
Sarnia WPCP	44.4	0.5	0.137	0.5	-	4.32[b]	0.742	0.118	0.009	-	-
Corunna WPCP	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Courtright WPCP	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Sombra Lagoon	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Port Lambton Lagoon	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
MICHIGAN MUNICIPAL SECTOR											
Port Huron WWTP	2.42	0.23[b]	-	0.018[b]	0.31[b]	-	-	ND[b]	0.0019	-	ND[b]
Marysville WWTP	-	-	-	-	ND[b]	-	-	ND[b]	0.0002[b]	-	-
St. Clair WWTP	0.15	-	-	-	ND[b]	0.327[b]	-	ND[b]	-	-	ND[b]
Marine City WWTP	-	-	-	-	1.8[b,d]	-	-	ND[b]	0.0003[b]	-	-
St. Clair-Algonac WWTP	-	-	-	-	ND[b]	-	-	ND[b]	ND	-	-

Table 8.1 (Cont'd)

Major Sources	Zinc	Nickel	Cadmium	Cobalt	Cyanide	Phenols	Volatiles	PAHs	PCBs	HCB	OCS
MICHIGAN INDUSTRIAL SECTOR											
James River KVP	-	-	ND[b]	-	ND[b]	-	-	ND[b]	0.0003[b]	-	-
E.B. Eddy Paper	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Akzo Salt	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Detroit-Edison/St. Clair	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Detroit-Edison/Belle	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Detroit-Edison/Marysville	-	-	-	-	-	-	-	-	-	-	-
TOTAL POINT SOURCE LOADS	68.09	3.465	0.1909	1.188	2.954	9.494	205.982	0.518	0.0149	0.0208	0.0135
TOTAL NONPOINT SOURCE LOADINGS	6.658	0.408-0.663	0.024-0.132	0.0-0.412	1.8	0.332-0.373	-	0.143-0.203	0.0038-0.0041	0.002	0.00004
TOTAL LOADINGS TO ST. CLAIR RIVER	74.75	3.873-4.128	0.2149-0.3229	1.188-1.600	4.754	9.826-9.867	205.982	0.661-0.721	0.0187-0.0190	0.0228	0.01354
TOTAL LOADINGS UGLCCS (1988)	51.6	4.85-5.03	0.169-0.31	0.86-1.27	5	12.53-12.57	254	0.478-0.538	0.0138-0.019	0.032	0.00494

- = data not available; ND = below detection limit; 0 denotes influent ≥ effluent.

a Data for this table have been taken from several sources representing a range in sampling periods and, hence, caution must be exercised in interpreting results. The table was generated by inserting the most recent loadings information into the loadings table prepared in UGLCCS (1988). Nonpoint source loadings reported as for UGLCCS (1988). Available information has been presented. The absence of data does not preclude the potential presence of a contaminant in listed discharges. Where loadings were not available, but contaminants are suspected to be present in a discharge, loadings may be underestimated.

Updated loadings sources and dates as follows:

Ontario WPCPs: - Tables 8.3 and 8.4 (1988 and 1987); remainder UGLCCS (1988)
Michigan: - calculated based on MDNR Discharge Monitoring Reports 1989); and UGLCCS 1986 data.
Petroleum Sector: - all but volatiles, PCBs and zinc from Table 8.30 (1988); zinc, PCBs and volatiles (from BTXE parameter) Table 8.17 (1988/89).
Organic Sector: - oil and grease, TP, NH_3, SS and phenols from Table 8.30 (1989); cadmium, mercury, HCB, OCS and total volatiles Table 8.31 (1986/87).
Inorganic Sector: - oil and grease, TP, NH_3, SS and phenols from Table 8.30 (1989); remainder UGLCCS (1986 data).

b Data from UGLCCS 1986 survey (Point Source Workgroup 1988).

c Data for Ontario point sources are net loads (i.e., outfall minus intake) with the exception of those marked by this footnote which are gross loadings; all Michigan point source data are gross loadings.

d This is based on the loadings calculated for the UGLCCS 1986 survey which found and elevated concentration of total cyanide (270 µg/L). This was the result of cyanide-containing waste water from an industrial source which was not properly pretreating its waste-water prior to discharge. Through the City's IPP program, the industry was brought into compliance with the ordinance limits and the concetrations in the WWTP final effluent have returned to normal. (Point Source Workgroup UGLCCS 1988). More recent cyanide loadings data are not available for this facility.

8.2 POINT SOURCES

The locations of major Ontario and Michigan point source dischargers to the St. Clair River are shown in Figure 8.1.

In Michigan, there are five municipal Wastewater Treatment Plants (WWTPs) including the Marine City, Marysville, Port Huron, St. Clair County-Algonac and St. Clair WWTPs. Six industrial facilities which discharge to the Michigan side of the St. Clair River are discussed in this section. These include three electric generating stations, two paper companies and a salt processing facility.

In Ontario, point sources include 27 industrial facilities encompassing the organic chemicals, inorganic chemicals, petroleum refining and electric generating sectors. There are also four Water Pollution Control Plants (WPCPs) and two sewage lagoons which discharge to the Ontario side of the St. Clair River or its tributaries. The WPCPs include facilities at Point Edward, Sarnia, Corunna and Courtright. Sewage lagoons, which discharge intermittently, occur at Sombra and Port Lambton (Figure 8.1).

8.2.1 Regulation Summary

8.2.1.1 Ontario Regulation Summary

The Ontario Ministry of the Environment (OMOE) employs a variety of measures to achieve compliance with its requirements, ranging from voluntary measures, formal programs, Control Orders, Requirements and Direction, and Certificates of Approval (CofA) to prosecution. This will be expanded when the Municipal-Industrial Strategy for Abatement (MISA) sets minimum legal requirements for dischargers across the province. The implementation of pollution control is a cooperative Federal/Provincial endeavour (Figure 8.2).

Historically, for most sources, Ontario has taken an effluent guidelines approach in setting provincial requirements. This approach, which was incorporated into the "Industrial Guidelines", was based initially on experience with municipal sewage treatment systems. It was presumed that treated industrial effluents should have the same pollutant concentrations as tested municipal effluent. However, since industrial effluents are quite different from municipal effluents in regard to specific pollutants, pollutant concentration and volume flow, application of the same treatment technology did not result in similar treated effluent concentrations. Facilities were evaluated on an individual basis through the CofA process. Both concentrations and loadings were considered.

Ontario also uses a "water quality approach" in setting effluent limits. In the case of biodegradable pollutants, every river or lake has a definable dilution, dispersion or assimilation (self-purification) capacity for non-persistent waste discharges. Water quality considerations take precedence when biodegradable discharges exceed the assimilative capacity of the receiving waters, but are within the limits set by federal guidelines or regulations. In these cases more stringent requirements, based on the assimilative capacity, are used to set effluent loading limits. Some of these biodegradable compounds are defined as toxic organics. The degree of biodegradation varies for specific compounds.

Where there are no legal limits, the OMOE may recommend a requirement based on best professional judgement. This incorporates a review of the manufacturing technology, effluent treatment technology and past performance. The facility will have demonstrated that its effluent quality can be controlled at lower limits than those in any guidelines.

Figure 8.1

St. Clair River Remedial Action Plan

Location of major point source dischargers to the St. Clair River

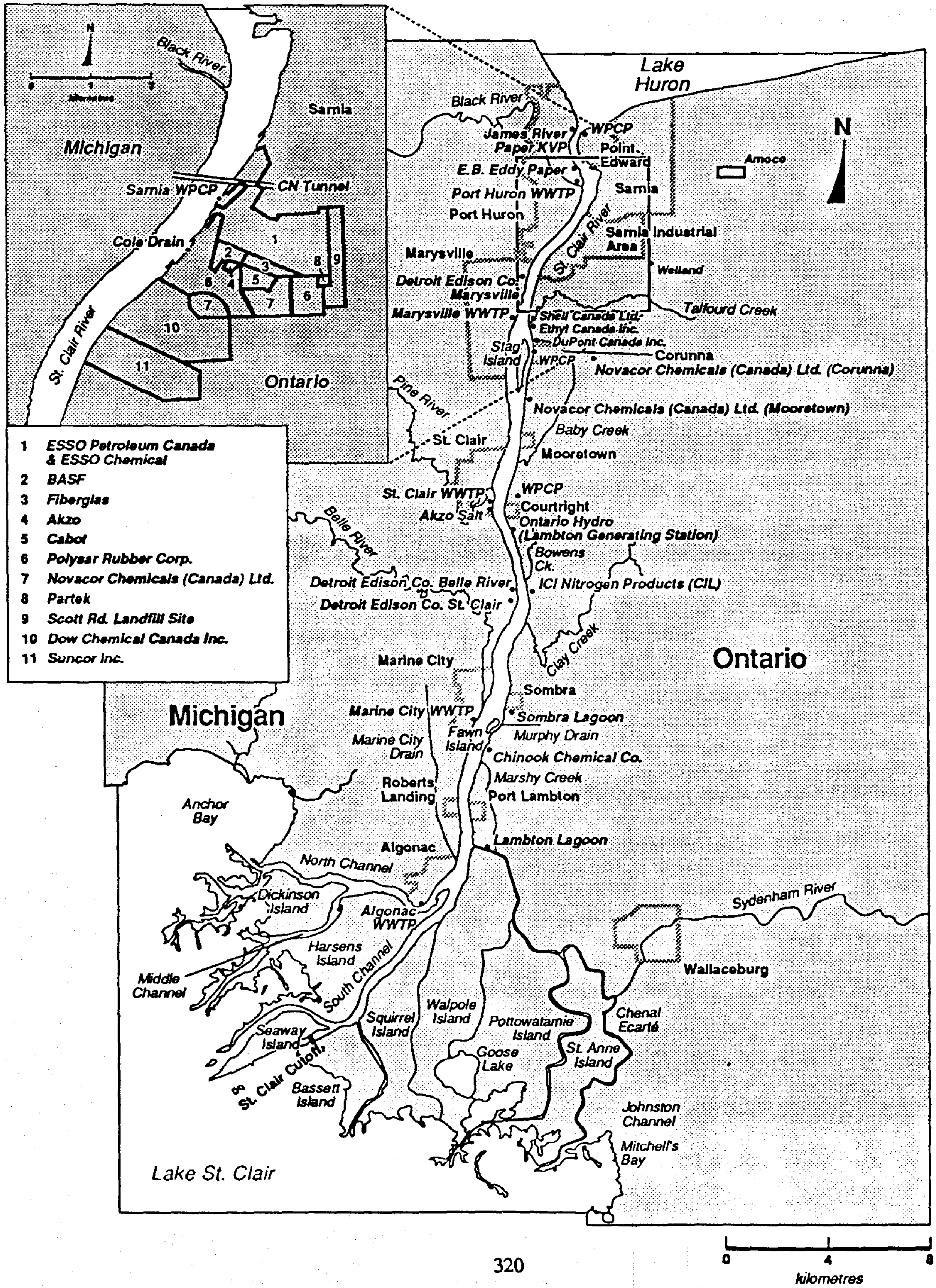
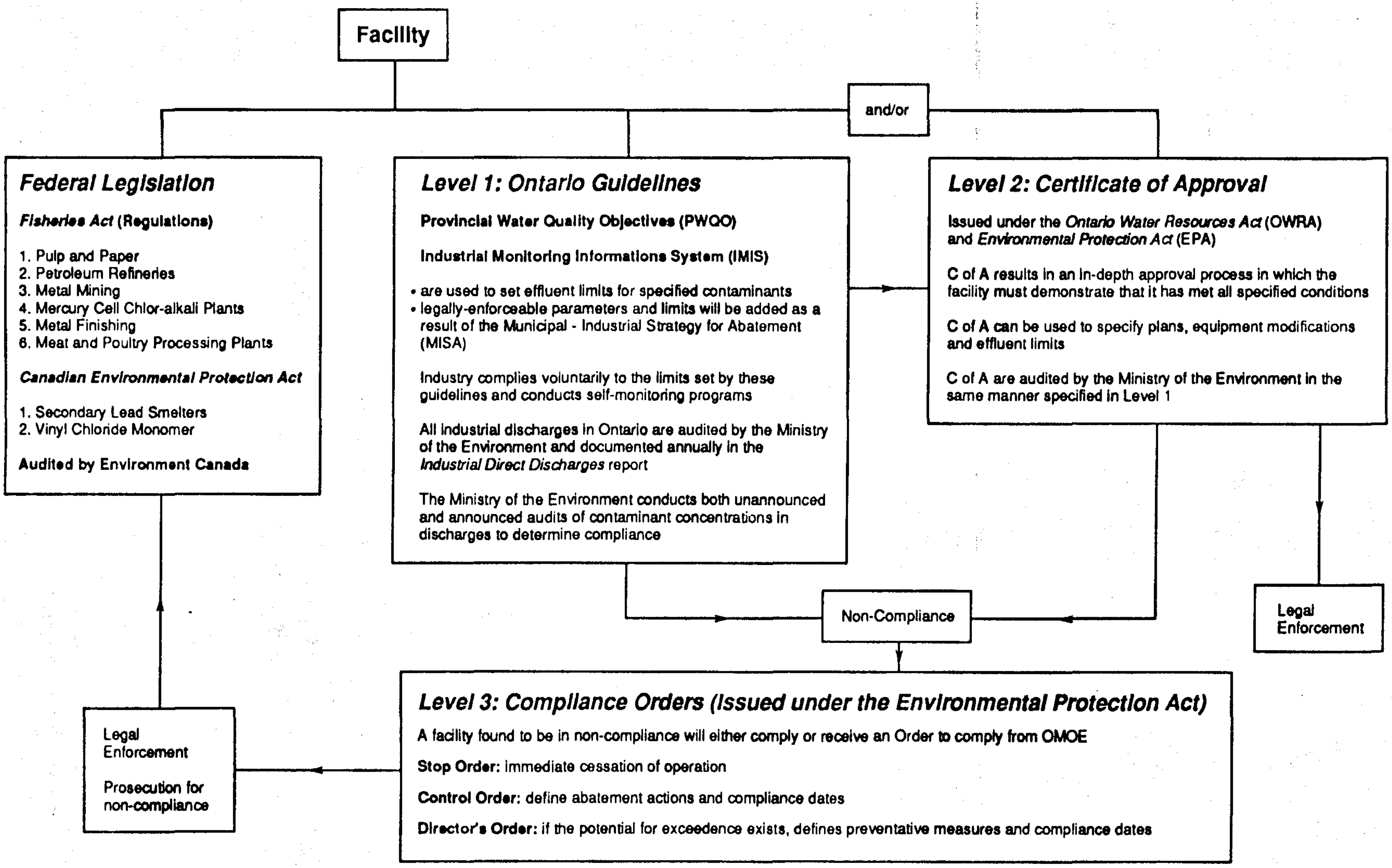


Figure 8.2

St. Clair River Remedial Action Plan

Schematic diagram of the legislative network used in Ontario to determine, monitor and, if necessary, enforce contaminant limits in effluent



In instances where innovative technology is being tried, the limits and/or conditions are normally set out in a CofA. Best professional judgement would also be used in this case. Thus, limits to the various discharges are set in several forms: Pollutant concentrations (milligrams per litre, mg/L), pollutant loadings (kilograms per day, kg/d), load per unit of production (kilograms related to production rate), and radioactive loadings (becquerels per litre per day). These limits may be based on any of the above rationales.

Legally-enforceable Control Orders and/or Director's Orders may be issued to any existing plant. Control Orders define abatement actions and compliance dates by which these actions must be completed. Legally-enforceable requirements and directions may also be issued.

The CofA for wastewater treatment plants are issued under the *Ontario Water Resources Act* and are legally-enforceable. The CofA for landfills or any project involving the emission of a contaminant to the air may be issued under the *Environmental Protection Act*. Municipal sewage treatment facilities are regulated by provincial policy specific to the type of plant.

All of the 27 industries currently have one or more CofA in place which are facility-specific. These certificates are legal documents, of which some establish discharge limits (criteria) for individual parameters. The Province of Ontario is currently requiring all industrial and municipal sectors to undergo detailed monitoring of a wide range of parameters, including heavy metals, conventional pollutants and organic chemicals, in order to establish sector-based and facility-based regulations for effluents discharged into rivers and lakes. This is the Municipal-Industrial Strategy for Abatement (MISA) Program which is described in more detail in Chapter 4. Each of the 27 industries is currently undergoing evaluation under this program. Most of the data collected under the MISA monitoring program have yet to be summarized or evaluated and, hence, are not available for this document.

8.2.1.2 Federal

The *Fisheries Act*, either the sector specific regulations/guidelines or the general provision (section 36(3)) prohibiting the deposit of deleterious substances to fish habitat waters, is applicable to the industries, municipalities and all other dischargers in the St. Clair RAP area. The sector specific regulations and guidelines promulgated under the *Fisheries Act* are as follows

Pulp and Paper Effluent Regulations
Petroleum Refineries Effluent Regulations and Guidelines
Metal Mining Effluent Regulations and Guidelines
Chlor-Alkali Mercury Liquid Effluent Regulations
Metal Finishing Liquid Effluent Guidelines
Meat and Poultry Processing Plants Effluent Regulations and Guidelines

Under the Canadian Environment Protection Act (CEPA) there are currently two industry sector specific regulations which limit releases to the atmosphere. These regulations are:

Vinyl Chloride Release Regulations
Secondary Lead Smelters Release Regulations

These sector specific regulations apply to all facilities in Canada which can be included in the industrial sector definition in the regulations.

The regional office of Environment Canada is responsible for ensuring compliance with Federal legislations in the province of Ontario. A formal federal-provincial administrative agreement does not currently exist for either the *Fisheries Act* (general prohibitions sections 36(3), sector specific regulations and guidelines) or CEPA. In general, however, the provincial certificate of approval process allows for consideration of federal requirements covered under the *Fisheries Act*.

8.2.1.3 Michigan Regulation Summary

Michigan point sources include 11 major facilities, five municipal and six industrial, discharging to the St. Clair River. All dischargers to the surface waters of the State of Michigan are required to have a National Pollutant Discharge Elimination System (NPDES) permit to ensure that Michigan's Water Quality Standards (WQS) are met in the receiving waters. These standards are established to protect designated uses including agriculture, navigation, industrial and public water supply, warmwater fish, other indigenous aquatic life and wildlife, and partial body contact recreation, as a minimum. Rule 57 of the WQS protects aquatic life, terrestrial life and human health from toxic substances.

A permit application characterizing the effluent must be submitted to the Surface Water Quality Division. This triggers a review of the facility, processes used and materials which may be in the effluent. The NPDES permit requirements may include:

1) limits for specific parameters that are presently in the discharge which have a reasonable potential of being acutely toxic at the end of the outfall pipe, or exceeding Michigan's WQS (including chronic toxicity) outside the designated mixing zones;

2) whole effluent toxicity limits;

3) monitoring of limited parameters to evaluate compliance;

4) monitoring (biological and/or chemical) for a specific period of time to further characterize the effluent; and

5) special conditions such as minimization plans for highly bioaccumulative materials or biouptake studies.

In addition to water quality based effluent limits, treatment technology concerns for each industrial category must be met. A more complete description of this process is provided in Chapter 4.

All of the NPDES permits issued to facilities discussed in this chapter contain effluent limits, monitoring requirements and other special conditions. A copy of the NPDES permit for each facility is provided in Appendix 8.1. Effluent limits and monitoring requirements are provided in the appropriate point source discussion. A summary of the special conditions required in each of the eleven NPDES permits is provided in Table 8.2. Each permit states that effluent discharges shall not physically or chemically alter in-stream characteristics. Should degradation occur, immediate steps to remedy the noncompliance shall be taken by the permittee and the permittee must notify the MDNR. Any changes in facility operations or sewerage system users that result in increased levels of any chemical must be reported to MDNR. Also, these NPDES permits do not authorize discharges of any type to the groundwater.

Results of monthly self-monitoring, waste characterization studies and Compliance Sampling Inspections are used to assess each facility's compliance with its permit and to set additional permit limits and monitoring requirements. Routine biomonitoring studies are conducted by MDNR and the results are used to develop any permit requirements for biomonitoring programs. Under Rule 82 of the WQS, facilities are not allowed to discharge effluent that would cause acute toxicity in the mixing zone, while Rule 57 prevents facilities from discharging effluent that would be chronically toxic to organisms in the receiving water. Facilities discharging effluent that is acutely or chronically toxic, or is close to being toxic, are required (by NPDES permit) to develop biomonitoring programs. If the biomonitoring program documents exceedences of Rules 57 or 82, the facility is required to develop and implement a Toxicity Identification/Reduction Evaluation (TI/RE) plan.

Table 8.2 Summary of special conditions within NPDES permits for the five major WWTPs and six major industrial dischargers to the St. Clair River from Michigan (C=facility in-compliance; P=facility requirement when applying for reissued permit; blank indicates that the NPDES permit does not include that requirement).

Facility	IPP	PERM	CSO	STWCS	Intake Structure Study	Toxicity Control Plan (TI/RE)	Settleable Solids Study	Acute Toxicity Testing	Toxicity Testing for Water Additives	Long Term Compliance Plan for PCBs	Whole Effluent Toxicity Testing
Port Huron WWTP	C	C	C							C	P
Marysville WWTP	C	C	C								P
St. Clair WWTP		C	C	C							P
Marine City WWTP	C	C	C								P
St. Clair-Algonac WWTP		C									P
AKZO Salt								C			
DECO-Belle River				C	C		C				
DECO-Marysville				C							
DECO-St. Clair				C							
E.B. Eddy Paper						C		C	C		
James River KVP				C				C			

IPP = Industrial Pretreatment Program.
PERM = Program for Effective Residuals Management.
CSO = Combined Sewer Overflow Control Program.
STWCS = Short Term Wastewater Characterization Study.

8.2.2 Municipal Point Sources

Five day biochemical oxygen demand (BOD5), suspended solids (SS) and total phosphorus (TP) have traditionally been used as indicators of municipal wastewater treatment plant performance and effluent quality. These parameters, among others, are used by the Ontario Ministry of the Environment (OMOE) and the Michigan Department of Natural Resources (MDNR) to assess compliance.

"The strength of wastewater is measured by the BOD5 test. This is the amount of oxygen required by microorganisms to reduce the organic content in sewage to carbon dioxide, measured over a 5 day period. High BOD concentrations in the effluent are an indication of high organic content remaining in the effluent and, therefore, ineffective treatment. Discharge of such effluent may cause oxygen depletion in receiving waters and other environmental impairment.

Removal of suspended solids in sewage effluent is important because excessive amounts of solids discharged to a water course can cause aesthetic problems and kill fish by clogging their respiratory passages (gills). Also, many trace contaminants such as metals and toxic organics are often adsorbed on the solids.

Total phosphorus has been identified as a major factor in the eutrophication of receiving waters. Excessive amounts of phosphorus cause rapid growth of algae and weeds. When algae and weeds die they decompose and use up dissolved oxygen. Lack of dissolved oxygen can kill aquatic organisms" (OMOE 1988a).

8.2.2.1 Ontario Municipal Point Sources

Canadian WPCPs which discharge directly to the Area of Concern, are the Point Edward, Sarnia, Corunna and Courtright WPCPs. The Sombra and Port Lambton Lagoons also discharge treated waste into the St. Clair River. Recent annual average loadings data for BOD5, suspended solids (SS) and total phosphorus (TP) are provided in Table 8.3. Ontario WPCPs are required to sample their effluent and influent at least once per month for analysis by OMOE (OMOE 1989a). Many facilities supplement this with additional analysis at their own laboratories.

Loadings of BOD_5, SS and TP have decreased over the period of record at five of the six facilities (Table 8.3). Although loadings decreased between 1987 and 1988 at Point Edward, increases between 1988 and 1989 amounted to 22.6 percent for BOD_5, 27.6 percent for SS and 48.2 percent for TP.

Point Edward WPCP

This WPCP is operated by the Ontario Ministry of the Environment. It is a primary treatment facility with continuous phosphorus removal. Point Edward WPCP discharges directly to the St. Clair River and has a design treatment capacity of 2,590 m^3/d (673,400 U.S. gal/d). The provincial guideline requires 50 percent removal of BOD5, 70 percent removal of SS (based on an annual average removal) and a maximum effluent concentration of 1 mg/L for TP (based on monthly averages). The Point Edward WPCP services a primarily residential area.

In 1987 the Point Edward WPCP was in compliance for BOD_5 and SS during all months, but exceeded the criterion for TP during 10 months. In 1988, the WPCP was in compliance for only SS. BOD5 exceeded the criterion during 9 of 12 months, although the plant is assessed only annually for this parameter. On an annual average basis, the plant percent removal of BOD5 was 30 percent in 1988. TP exceeded the criterion for 11 months during 1988. During 1989, the criteria for all three parameters were exceeded. Average annual SS removal was 43 percent and BOD_5 removal was only 21 percent. Total phosphorus exceeded the 1.0 mg/L criterion during 11 months with average concentrations in excess of 3.0 mg/L occurring during 5

Table 8.3 Average annual 1987 and 1988 net loadings of BOD5, suspended solids and total phosphorus (kg/day) for the six Canadian WPCP's which discharge to the St. Clair River AOC (OMOE 1988a, 1989a and 1991b, Appendix 8.2).

Facility*		Flow (1000 m^3/d)	BOD5 (kg/d)	Suspended Solids (kg/d)	Total Phosphorus (kg/d)
Point Edward	-1987	1.74	101.88	76.79	3.23
	-1988	1.61	90.16	67.14	2.74
	-1989	1.56	110.60	85.64	4.06
Sarnia	-1987	54.60	2103.65	1300.81	47.30
	-1988	52.62	3388.73	1299.71	42.10
	-1989	35.64	2127.71	762.70	28.51
Corunna	-1987	2.18	14.99	16.28	0.83
	-1988	1.96	7.45	15.68	0.78
Courtright	-1987	0.69	7.61	10.58	0.29
	-1988	0.65	3.84	8.26	0.26
Sombra Lagoon	-1987	0.21	1.32	12.91	0.08
	-1988	0.20	3.40	15.56	0.10
	-1989	0.19	0.42	2.30	0.02
Port Lambton Lagoon	-1987	0.42	5.41	48.64	0.35
	-1988	0.38	4.71	17.82	0.34
	-1989	0.42	0.67	4.37	0.08

* All facilities are operated by OMOE except for the Sarnia WPCP which is operated by the municipality.

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months. Average daily flows did not exceed the plant capacity in any month during 1987, 1988 or 1989. Table 8.3 provides the average annual loadings for this facility.

There is cause for concern in the fact that the Point Edward WPCP consistently exceeds the guideline (Appendix 8.2). The plant is currently undergoing expansion in order to meet its compliance requirements. Completion is expected to be in mid-1992. The hydraulic capacity will be increased to 4,550 m^3/d (0.161 X 10^6 ft^3/d). The design effluent concentrations are: BOD_5, 10 mg/L; suspended solids, 10 mg/L; total phosphorus, 0.8 mg/L; and ammonia-nitrogen, 2 mg/L.

The UGLCCS (1988) point source survey, which was conducted during 1986, identified effluent concentrations at the Point Edward WPCP as exceeding the Ontario Municipal Effluent Objective of 20 μg/L for total phenols (3 to 6 day sampling period).

Sarnia WPCP

This WPCP is a primary treatment facility with continuous phosphorus removal. It is operated by the municipality. The Sarnia WPCP discharges directly to the St. Clair River and has a design treatment capacity of 65,910 m^3/d (2.328 X 10^6 ft^3/d). The effluent guideline is the same as for the Point Edward WPCP. The Sarnia WPCP receives the effluent from a combination of residential (19%), commercial (8%) and small industrial users (7%) as well as unaccounted sources (65%) including infiltration (Canviro Consultants 1989). The unaccounted sources category may be over-estimated due to problems encountered with the previous plant flow meter.

In 1987, the Sarnia WPCP was in compliance for TP, BOD5 and SS during all months. In 1988, the plant was in compliance for suspended solids and TP in all months. The 1988 data were insufficient to determine compliance for BOD5, however, the annual percent removal was better than the criterion (50%), averaging 62 percent during the eight months for which data are available. During 1989, both BOD_5 (60%) and SS (86%) were in compliance, however, the criterion for TP was exceeded during one month (1.1 mg/L). The design treatment capacity was not exceeded during 1987, 1988 nor 1989 (OMOE 1988a, 1989a, 1991b). The average annual loadings for the Sarnia WPCP are reported in Table 8.3.

UGLCCS (1988) identified the Sarnia WPCP as a 'principal contributor' of phosphorus to the St. Clair River. The 1986 average loading of TP reported for this facility was 43.6 kg/d (UGLCCS 1988). This is within the range reported for 1987 and 1988 but the 1989 loading of TP was substantially lower at 28.51 kg/d (Table 8.3).

The BOD5 for the Sarnia WPCP increased from 1987 to 1988 the declined again during 1989 (Table 8.3). The total from both the Sarnia and Point Edward facilities remains well below the 1986 data reported in UGLCCS (1988) for the Canadian municipal direct loadings (5,700 kg/d).

Results of the 21 day (January-February 1987) MISA Monitoring Study for the Municipal Sector (Canviro Consultants 1989) includes metals and organics data for the Sarnia WPCP (Table 8.4).

The Sarnia WPCP was identified by UGLCCS (1988) as a "principal contributor" of nickel and was also the largest source of zinc to the St. Clair River. Data from the MISA municipal sector monitoring study indicates that this WPCP continued to serve as a major source of both metals into early 1987. The loading for zinc during the 1987 MISA study (44.4 kg/d) was more than twice as high as during the UGLCCS point source survey in 1986 (19.7 kg/d). The loading of nickel decreased by almost half from 1986 (0.973 kg/d) to 1987 (0.5 kg/d), however, it was still comparable to that discharged by Dow and Polysar during the UGLCCS survey. UGLCCS (1988) identified the Sarnia WPCP as exceeding the Ontario Municipal Effluent Objectives of 20 ug/L for total phenols and 10 mg/L for ammonia-nitrogen during the 1986 point source survey.

Geometric mean concentrations of copper, zinc, aluminum, lead, cobalt and total PCBs in the effluent of the Sarnia WPCP exceeded the respective Provincial Water Quality Objective (Table 8.4). The PWQO are set on the basis of protection of aquatic life and recreation in surface waters and are not directly applicable to effluent concentrations. However, impacts may occur at the point of discharge into the river. Of particular concern was the mean concentration of zinc which exceeded the PWQO by almost 30 times.

Corunna WPCP

The Corunna WPCP is an extended aeration treatment facility with continuous phosphorus removal. It is operated by OMOE. The plant discharges directly to the St. Clair River and has a design treatment capacity of 4,540 m^3/d (1.18 X 10^6 U.S. gal/d). The provincial guideline requires an annual average effluent

Table 8.4 MISA Pilot Monitoring Study results for the Sarnia WPCP based on a 21 day sampling period ending February 6, 1987 (Canviro Consultants 1989).

Parameter	Ontario PWQO (μg/L)	Geometric Mean (μg/L)	Minimum (>DL) (μg/L)	Maximum (μg/L)	Loading (kg/d)[1]
Copper	5	20	20	20	1.0
Zinc	30	880	670	1300	44.4
Aluminum	75	200	120	410	10.1
Mercury	0.2	0.1	0.04	0.1	0.005
Lead	25	90	70	140	4.5
Cobalt	5	10	10	10	0.5
Chromium	100	10	10	10	0.5
Nickel	25	10	10	10	0.5
Total PCBs	0	0.18	0.05	0.45	0.009
δ-BHC	0.06	0.01	0.02	0.04	0.0005
o-Xylene	100	3.69	2.8	5.6	0.19
m+p-Xylenes	-	1.55	3.7	3.7	0.078
1,1,1-Trichloroethane	-	1.55	3.7	3.7	0.078
Tetrachloroethylene	-	6.55	4.1	12.0	0.33
Chloroform	-	1.3	2.2	2.2	0.066

[1] Loadings calculated from the geometric mean and the February 1987 reported average daily flow of 50,497 m^3 (13.13 X 10^6 U.S. gal)(OMOE 1988a).

concentration of 25.0 mg/L for both BOD5 and SS, and a monthly average of 1.0 mg/L for TP. The Corunna WPCP serves a residential population of up to 6,000.

In 1987 and 1988, the Corunna WPCP was in compliance for BOD, SS and TP during all months. Average daily flows were only up to half the design capacity for the WPCP in both 1987 and 1988. Loadings to the St. Clair River are relatively small when compared to those of the Sarnia and Point Edward WPCPs (Table 8.3).

Courtright WPCP

The Courtright WPCP is an extended aeration treatment facility with continuous phosphorus removal. It is operated by the OMOE. Effluent is discharged directly into the St. Clair River and the plant has a design treatment capacity of 680 m^3/d (176,800 U.S. gal/d). The CofA requires a maximum allowable effluent concentration of 25.0 mg/L for both BOD5 and SS, and a monthly average of 1.0 mg/L for TP. The Courtright WPCP serves a residential population of 1,500.

In 1987 and 1988, the Courtright WPCP was in compliance for BOD, SS and TP during all months except July 1988, in which the SS criterion was exceeded (Appendix 8.2). Average daily flows were nearly double the plant's capacity during the last three months in 1987 and exceeded the plant's capacity during 5 months in 1988 resulting in by-passes (Appendix 8.2). Loadings to the St. Clair River from the Courtright WPCP are relatively small when compared to those of the Sarnia and Point Edward WPCPs (Table 8.3).

Sombra Lagoon

The Sombra Lagoon is a conventional lagoon with batch phosphorus removal. The lagoon serves a residential population of 700 and is operated by the OMOE. It discharges directly into the St. Clair River and has a design treatment capacity of 960 m^3/d (249,600 U.S. gal/d). The provincial guideline requires an annual average effluent concentration of 25.0 mg/L for both BOD5 and SS, and a monthly average of 1.0 mg/L for TP. Discharges occur seasonally with samples taken monthly during the season of discharge. In 1987 the lagoon discharged during April, October and November whereas in 1988 and 1989 discharge occurred only during April.

In 1987 and 1988 the Sombra Lagoon was in compliance for BOD and TP. SS concentrations exceeded the concentration criterion twice in 1987 and during the only month of discharge in 1988 (Appendix 8.2). The Sombra Lagoon was in compliance for all three parameters during 1989. Annual average loadings are shown in Table 8.3.

Port Lambton Lagoon

This is a conventional lagoon with batch phosphorus removal. The Port Lambton Lagoon serves a residential population of 1,000 and is operated by the OMOE. It discharges directly into the St. Clair River and has a design treatment capacity of 1,080 m^3/d (280,800 U.S. gal/d). The provincial guideline requires an annual average effluent concentration of 25.0 mg/L for both BOD5 and SS, and a monthly average of 1.0 mg/L for TP. Monthly discharges occurred during April and November of 1987, during April of 1988 and during April, October and November of 1989.

In 1987 and 1988 the Port Lambton Lagoon was in compliance for BOD and TP during all months of sampling. SS concentrations exceeded the concentration criterion on all three occasions (Appendix 8.2). All three parameters were in compliance during 1989. Table 8.3 provides the average annual loadings of BOD_5, SS and TP from this lagoon to its effluent receiver (Marshy Creek).

8.2.2.2 Michigan Municipal Point Sources

There are five major municipal Wastewater Treatment Plants (WWTPs) discharging to the St. Clair River from Michigan. These include the Port Huron, Marysville, St. Clair, Marine City and St. Clair County-Algonac WWTPs. These facilities are required by their NPDES permits to comply with several special conditions (Table 8.2). Applicable implementation dates are provided in each NPDES permit (Appendix 8.1).

The first special condition relates to pretreatment of industrial waste. Three of the five facilities (Port Huron, Marysville and Marine City) are required to implement an industrial waste pretreatment program. This condition details the municipal facility's responsibility to assure that all non-domestic effluent sources entering the sewage system be documented and controlled to comply with established limits, either federal or local. The permittee must maintain records and information for three years on all monitoring and enforcement activities, and must annually review and modify the pretreatment program for present and future adjustments. The permittee shall include this information in the Annual Pretreatment Summary Report submitted to the Surface Water Quality Division, MDNR. St. Clair County-Algonac and St. Clair

WWTPs are not required to develop industrial pretreatment programs. However, the permittees are required to report any discharges or proposed discharges that would result in a pretreatment requirement. The permits may be modified, if necessary.

A second special condition contains the requirement for the facility to implement a Program for Effective Residuals Management. This outlines effective methods for management and/or disposal of WWTP residuals (i.e. solids, sludge, ash, grit and other materials removed as part of the wastewater treatment process). The program is designed to accomplish safe disposal of potential pollutants including a materials management plan, yearly residual production, storage and disposal locations, residuals analysis and monitoring program, and hydrogeologic studies for areas of groundwater concern.

Specific requirements for implementation of the Combined Sewer Overflow Program are contained in the NPDES permits for Marine City, Marysville, Port Huron and St. Clair (Appendix 8.1). The CSO Program is discussed in general terms in Chapter 4.

Table 8.5 provides the estimated daily loadings to the St. Clair River and its tributaries for 1988 and 1989 from the five major Michigan WWTPs. The loadings were calculated using the monthly discharge monitoring reports (DMRs) provided by the facilities. The DMRs are based on self-monitoring requirements put forth in the individual NPDES permits (Appendix 8.1). Average daily loads were calculated in most cases. However, median loads were calculated when data for one or more months were reported in the DMR as below the analytical level of detection, not detected, or zero. Loadings provided in Table 8.5 are gross effluent loadings. Although net loadings would provide the best indication of contaminant loadings from each facility, intake data, required in order to calculate net loads, were not available.

Generally, loadings were calculated based on average effluent flows and concentrations. In some cases, however, loadings are reported directly by the facility. Where effluent concentrations were below the analytical detection limit, loadings were calculated using the level of detection as the reported concentration and the load is reported as less than (<) the value shown. The flows and concentrations used to calculate the point source loads are presented in Appendix 8.2. This appendix also provides the loading values in both metric (kg/d) and imperial (lbs/d) units.

Port Huron WWTP

The Port Huron WWTP is an activated sludge secondary treatment plant with chemical phosphorus removal. Plant operations include bar screens, aerated grit chambers, primary clarifiers, activated sludge aeration tanks, secondary clarifiers and chlorination. Sludges are land applied during the appropriate seasons and incinerated during the wintertime. Ash from the incineration process is hauled to a licensed landfill. The plant serves 50,000 people and has a design and average flow of 20 and 12 MGD (75.7 and 45.4 X $10^3 m^3/d$), respectively. The facility is regulated under NPDES Permit No. MI 0023833 issued September 17, 1987 and modified on June 25, 1990.

The Port Huron permit establishes effluent limits for several parameters including copper and zinc (Table 8.6). Both of these metals were found in the effluent during a wastewater survey conducted at the facility in 1985. The permit also requires the facility to monitor its effluent semimonthly for PCBs and to implement the approved long term compliance plan for reducing PCBs in effluent to below 1.2 x 10-5 $\mu g/l$. This requirement is incorporated into the permit to minimize the introduction of PCBs into the sewer system. As of July 1, 1990, the facility is not allowed to discharge PCBs in excess of the detection limit (0.5 $\mu g/l$). The facility has maintained compliance with this limit.

Table 8.5 Average daily 1988 and 1989 loading (kg/d) from the five major Michigan WWTPs which discharge to the St. Clair River and its tributaries (Michigan Department of Natural Resources 1990). Appendix 8.2 provides monthly data on each facility as well as annual averages in imperial measure (lbs/d).

Facility	Flow (MGD)	BOD_5	Carbonaceous BOD_5	Suspended Solids	Total Phosphorus	Total Residual Chlorine	Copper	Lead	Mercury	Zinc	Total PCBs
Port Huron -1988	10.730	_	165.0	206.0	28.00	21.83	0.73	-	-	4.32	<0.0023**
-1989	10.980	_	184.0	250.0	25.00	22.80	0.64	-	-	2.42	0.0019*
Marysville -1988	1.480	125.0	_	38.0	4.33	1.08*	-	-	-	-	-
-1989	2.270	206.0	_	76.0	6.17	1.34	-	-	-	-	-
St. Clair											
St. Clair R. -1988	0.663	38.9	-	61.1	1.83	0.56	-	-	-	-	-
-1989	0.933	39.8	28.8	48.5	2.72	0.78	-	0.23	-	0.15	-
Pine River -1988	0.479	23.0	-	35.0	1.02	0.48	-	-	-	-	-
-1989	0.826	55.7	23.6	54.5	2.24	0.85	-	-	-	-	-
Marine City -1988	0.913	93.6	-	25.0	2.27	1.04	-	-	-	-	-
-1989	0.968	82.1	-	34.0	1.81	1.60*	-	-	-	-	-
St. Clair											
County/Algonac -1988	1.576	91.9	-	60.1	2.66	0.97	-	-	-	-	-
-1989	1.670	95.9	84.6	83.2	2.91	1.42	-	-	<0.000003**	-	<0.0003**

- = no data.
* one or more median value used in determining the load.
** concentrations of the parameter were below the detection level; loads were calculated using the detection level and monthly flow data; a median of these loads was taken.

Table 8.6 Port Huron WWTP effluent limitations and monitoring requirements on discharges to the St. Clair River. Permit No. MI0023833, issued September 17, 1987, modified June 25, 1990.

Outfall	Effluent Characteristic	Dates in Effect	Daily Min.	Daily Max.	30-Day Average	7-Day Average
100	Flow (MGD)	All Year	--	--	--	--
	Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	All Year	--	--	25 mg/l 4170 lb/d (1892 kg/d)	40 mg/l 6672 lb/d (3026 kg/d)
	Total Suspended Solids	All Year	--	--	30 mg/l 5004 lb/d (2270 kg/d)	45 mg/l 7506 lb/d (3405 kg/d)
	Total Phosphorus (as P)	All Year	--	--	1.0 mg/l	--
	Dissolved Oxygen	All Year	4 mg/l	--	--	--
	Fecal Coliform Bacteria	All Year	--	--	200/100 ml	400/100 ml
	Total Residual Chlorine	All Year	--	--	--	--
		All Year beginning 7/1/90	--	0.036 mg/l	--	--
	pH (standard units)	All Year	6.5	9.0	--	--
	Copper*	All Year	--	--	--	--
		All Year beginning 6/1/89	--	23 ug/l	--	--
	Zinc*	All Year	--	--	--	--
		All Year beginning 6/1/89	--	252 ug/l	--	--
103**	Flow (in MGD) +	All Year	--	--	--	--
	Biochemical Oxygen Demand (BOD_5) +	All Year	--	--	--	--
	Total Suspended Solids +	All Year	--	--	--	--
	Total Phosphorus (as P) +	All Year	--	--	--	--
	Dissolved Oxygen +	All Year	--	--	--	--
	Fecal Coliform Bacteria	All Year	--	--	200/100 ml	400/100 ml
	pH (standard units) +	All Year	--	--	--	--

* Recommended detection limits for Copper and Zinc are 20 and 50 ug/l, respectively.
** The discharge of treated sanitary sewage from this outfall (Retention Treatment Basin outfall) is authorized when Retention Treatment Basin is full and influent to the WWTP exceeds design treatment capacity. This path is technically possible, but never used under normal treatment processes.
+ Limits have not been set forth, daily measurements during discharge are required.

Requirements for the regulation and correction of discharges from its combined sewer overflow system are also included in the permit. The program is consistent with that outlined in Chapter 4 and requires submittal of a Final CSO Control Program by December 31, 1992.

Total suspended solids, total phosphorus, zinc, and PCBs are the parameters of concern discharged from this facility. The average annual loadings for total suspended solids and total phosphorus for 1988 and 1989 are shown in Table 8.5. The last Compliance Sampling Survey, conducted November 9-10, 1987, showed the facility was in compliance with its NPDES Permit and the discharge did not contain any organic or inorganic contaminants at levels of concern. The next Compliance Sampling Survey is scheduled for 1992.

Routine review of facility self-monitoring reports and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of the NPDES Permit with two exceptions. One, the facility has not signed a multijurisdictional agreement with one outlying township in its collection system required under the Industrial Pretreatment Program. Secondly, the facility is in noncompliance with its effluent limit for total residual chlorine pending action by the Water Resources Commission to modify its effluent limit.

Marysville WWTP

The Marysville WWTP is a trickling filter secondary plant with chemical phosphorus removal. Plant operations include screening, grit removal, primary settling, two trickling filters, secondary settling, and chlorination. Sludges are treated using aerobic digestion and disposed of by land application. The plant serves 8,000 people and has a design flow and average flow of 2.6 and 1.9 MGD (9.8 and 7.2 X $10^3 m^3/d$), respectively. The facility is regulated under NPDES permit No. MI0020656 issued May 24, 1990 (Appendix 8.1). Final effluent limits and monitoring requirements are listed in Table 8.7.

Mercury, zinc, PCBs, total suspended solids and total phosphorus are the parameters of concern discharged from this facility. Limits for metals and PCBs were incorporated into the Permit because they were detected in the effluent during the 1986 Compliance Sampling Survey. Monitoring is required to determine if these contaminants are being discharged in significant concentrations. The average annual loadings for these parameters for 1988 and 1989 are shown in Table 8.5. The last Compliance Sampling Survey, conducted July 29-30, 1986, showed the facility was in compliance with its NPDES permit and the discharge did not contain any organic or inorganic contaminants at levels of concern. The next Compliance Sampling Survey is scheduled for 1991.

As indicated in Table 8.2, the Marysville Permit also requires regulation and correction of discharges from its combined sewer overflow system. The program is consistent with that outlined in Chapter 4 and requires submittal of a Final CSO Control Program by October 1, 1992.

Routine review of facility self-monitoring reports and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of the NPDES Permit.

St. Clair WWTP

The St. Clair WWTP is a trickling filter secondary treatment plant with chemical phosphorus removal. Plant operations include grit removal, air flocculation, primary sedimentation, two trickling filters, and chlorination. Sludges are anaerobically digested then land applied according to approved procedures. The plant serves a population of 6,000 and has design and average flows of 1.4 and 1.3 MGD (5.3 and 4.9 X $10^3 m^3/d$), respectively. The facility is regulated under NPDES Permit No. MI 0020591 issued June 15, 1989 and modified May 24, 1990 (Appendix 8.1).

Final effluent limits and monitoring requirements established in the permit are summarized in Table 8.8. The St. Clair permit establishes effluent limits for several parameters including silver, lead, and zinc. The permit requires monitoring of these parameters on a quarterly basis. Special permit requirements are shown in Table 8.2.

Table 8.7 Marysville WWTP NPDES final effluent limitations on Outfall 001 discharges to the St. Clair River. Permit No. MI0020656, issued May 24, 1990.

Effluent Characteristic	Effluent Limitations			30-Day Average	7-Day Average
	Dates In Effect	Daily Minimum	Daily Maximum		
Flow (MGD)	All Year	---	(Report)	(Report)	---
Biochemical Oxygen Demand (BOD_5)	All Year	---	---	30 mg/l 651 lb/d 295 kg/d	45 mg/l 976 lb/d 443 kg/d
Total Suspended Solids	All Year	---	---	30 mg/l 651 lb/d 295 kg/d	45 mg/l 976 lb/d 443 kg/d
Total Phosphorus (as P)	All Year	---	---	1.0 mg/l	---
Dissolved Oxygen	All Year	4.0 mg/l	---	---	---
Fecal Coliform Bacteria	All Year	---	---	200/100 ml	400/100 ml
Total Residual Chlorine	All Year	---	0.5 mg/l	---	---
PCB's	All Year	---	monitoring only		---
Total Mercury	All Year	---	monitoring only		---
Total Copper	All Year	---	monitoring only		---
Total Zinc	All Year	---	monitoring only		---
pH (standard units)	All Year	6.0	9.0	---	---

Requirements for the regulation and correction of discharges from its combined sewer overflow system are included in the permit. The City is in the process of separating their sewer system to eliminate any combined sewer overflows presently in their system. The City of St. Clair is in Phase II of its program which is expected to be completed during the Summer of 1992.

A Short Term Waste Characterization Study (STWCS) was required in the NPDES Permit to provide additional information on possible PCBs in the effluent. The data from the PCB STWCS was submitted on December 14, 1990. The data indicated that there were no PCBs present at detectable levels in the sludge or wastewater.

Total suspended solids, total phosphorus, ammonia-N, zinc, and lead are the parameters of concern discharged from this facility. Lead was detected in the effluent during the 1986 Compliance Sampling Survey. The average loadings for total suspended solids and total phosphorus for 1988 and 1989 are shown in

Table 8.8 St. Clair WWTP NPDES final effluent limitations and monitoring requirements on Outfall 001 discharges to the St. Clair River. NPDES Permit Number MI 0020591, issued June 15, 1989.

Effluent Characteristic	Dates In Effect	Daily Minimum	Daily Maximum	30-Day Average	7-Day Average
Flow (MGD)	All Year	--	Monitor Only	--	--
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	All Year	--	--	25 mg/l 292 lb/d 133 kg/d	40 mg/l 466 lb/d 211 kg/d
Total Suspended Solids	All Year	--	--	30 mg/l 350 lb/d 159 kg/d	45 mg/l 525 lb/d 238 kg/d
Ammonia Nitrogen (as N)	All Year	--	--	Monitor Only	--
Total Phosphorus (as P)	All Year	--	--	1.0 mg/l	--
Dissolved Oxygen	All Year	4.0 mg/l	--	--	--
Fecal Coliform Bacteria	All Year	--	--	200/100 ml	400/100 ml
Total Residual Chlorine	All Year	--	0.5 mg/l	--	--
Silver	All Year	--	Monitor Only		--
Lead	All Year	--	Monitor Only		--
Zinc	All Year	--	Monitor Only		--
pH (standard units)	All Year	6.5	9.0	--	--

Table 8.5. The average monthly ammonia-nitrogen concentration ranged between 1.39 and 3.65 mg/l from January to December 1990. The zinc concentrations measured ranged between <10 to 60 μg/l, and lead between 60 and <130 μg/L.

The last Compliance Sampling Survey, conducted July 25-26, 1989 showed the facility to be in substantial compliance with its NPDES Permit and the discharge did not contain any organic or inorganic contaminants at levels of concern. Routine review of facility self-monitoring reports and periodic inspections by District personnel indicates that the facility is in substantial compliance with the terms and conditions of the NPDES permit.

Marine City WWTP

The Marine City WWTP is a trickling filter secondary treatment plant with chemical phosphorus removal. Plant operations include grit removal, primary sedimentation, two trickling filters, secondary clarifiers, and chlorination. Sludges are anaerobically digested then land applied according to approved procedures. The plant serves a population of 6,523 and has design and average flows of 1.6 and 1.8 MGD (6.1 and 6.8 X

10^3 m^3/d), respectively. The facility is regulated under NPDES Permit No. MI 0020893 issued September 22, 1989 (Appendix 8.1). Final effluent limitations and monitoring requirements are summarized in Table 8.9. Additional special programs and permit requirements are shown in Table 8.2.

Table 8.9 Marine City WWTP NPDES final effluent limitations and monitoring requirements on Outfall 001 discharges to the St. Clair River. NPDES permit number MI 0020893, issued September 22, 1989.

Effluent Characteristic	Dates In Effect	Daily Minimum	Daily Maximum	30-Day Average	7-Day Average
Flow (MGD)*	All Year	--	--	--	--
Biochemical Oxygen Demand (BOD_5)	All Year	--	--	30 mg/l 400 lb/d 181 kg/d	45 mg/l 600 lb/d 272 kg/d
Total Suspended Solids	All Year	--	--	30 mg/l 400 lb/d 181 kg/d	45 mg/l 600 lb/d 272 kg/d
Total Phosphorus (as P)	All Year	--	--	1.0 mg/l	--
Fecal Coliform Bacteria	All Year	--	--	200/100 ml	400/100 ml
Total Residual Chlorine	All Year	--	0.5 mg/l	--	--
pH (standard units)	All Year	6.0	9.0	--	--

*Flow in million gallons per day.

The City is in the process of constructing a new WWTP including replacement of the trickling filter treatment system with a new oxidation ditch treatment system. The City has applied for and received a $10.4 million loan from the State and Federal governments. Construction of the new plant is scheduled to begin in the Fall of 1991.

Requirements for the regulation and correction of discharges from its combined sewer overflow system are included in the permit. The City, through the requirements of a Final Order, will separate the combined sewers within their system by 1994.

Total suspended solids, total phosphorus, and toluene are the parameters of concern discharged from this facility. The average loadings for total suspended solids and total phosphorus for 1988 and 1989 are shown in Table 8.5. The last Compliance Sampling Survey, conducted July 25-26, 1989, showed the facility to be in substantial compliance with its NPDES Permit and the discharge did not contain any inorganic contaminants at levels of concern. However, low-level concentrations of toluene were discovered in the wastewater during the survey. District compliance staff are reviewing this information for possible administrative compliance actions.

Routine review of facility self-monitoring reports and periodic inspections by District personnel indicates that the facility is in substantial compliance with the terms and conditions of the NPDES permit.

The UGLCCS (1988) reported an elevated concentration of total cyanide (270 μg/L) in the Marine City WWTP effluent. The city determined that this was the result of cyanide-containing wastewater from an industrial source. The industry was not properly pretreating its wastewater prior to discharge. Through the city's IPP program, the industry was brought into compliance with the ordinance limits and the concentrations in the WWTP final effluent have returned to normal (Point Source Workgroup UGLCCS 1988).

St. Clair County-Algonac WWTP

The St. Clair Co.- Algonac WWTP is a rotating biological contactors (RBC) secondary treatment plant with chemical phosphorus removal. Plant operations include rough screening, comminutor, primary sedimentation, rotating biological contactors, secondary clarifiers and chlorination. Sludges are anaerobically digested then land applied according to approved procedures. The plant serves a population of 14,000 and has design and average flows of 2.7 and 1.6 MGD (10.2 and 6.1 X $10^3m^3/d$), respectively. The facility is regulated under NPDES Permit No. MI 0020389 issued June 15, 1989 (Appendix 8.1). Table 8.10 summarizes final effluent limitations and monitoring requirements as specified in the St. Clair Co.- Algonac permit. Additional special programs and permit requirements are shown in Table 8.2.

Total suspended solids, total phosphorus, mercury and PCBs are the parameters of concern discharged from this facility. The average loadings for total suspended solids and total phosphorus for 1988 and 1989 are shown in Table 8.5. The concentrations of PCBs and mercury for all samples collected in 1990 were less than the detection limit. These parameters were added to the last NPDES Permit because they were detected in the effluent during the 1986 Compliance Sampling Survey.

The last Compliance Sampling Survey, conducted July 25-26, 1989 showed the facility to be in substantial compliance with its NPDES Permit and the discharge did not contain any organic or inorganic contaminants at levels of concern.

Routine review of facility self-monitoring reports and periodic inspections by District personnel indicates that the facility is in substantial compliance with the terms and conditions of the NPDES permit.

8.2.3 Combined Sewer Overflows

Combined Sewer Overflows (CSOs) are sewers which combine stormwater runoff with sewage effluent. They contribute loadings to the river at specific points and, hence, are technically point sources. However, pollutant loadings within CSOs are derived from municipal wastewater treatment plants during high flow events as well as from rainfall and associated urban runoff. As such, sources to CSOs include nonpoint contributions. There are few data on loadings to the St. Clair River from CSOs. Limited loadings data for stormwater runoff (from storm sewers) and CSOs from Sarnia are available and these will be discussed in the nonpoint section under urban runoff (Section 8.3.4.1). Data to document the quality of effluent from CSOs from Michigan communities are not currently available.

There are 53 CSOs which drain either directly to the St. Clair River or indirectly via its tributaries. Sarnia has 4 CSOs, whereas in Michigan there are 21 in Port Huron, 3 in Marysville, 12 in St. Clair and 13 in Marine City. The location of the CSO outfalls are shown in Figure 8.3. The following is a brief descriptive account of CSOs.

Table 8.10 NPDES Permit final effluent limitations on Outfall 001 discharge to the St. Clair River from the St. Clair County-Algonac WWTP. NPDES permit No. MI0020389, issued June 15, 1989.

Effluent Characteristic	Dates In Effect	Daily Minimum	Daily Maximum	30-Day Average	7-Day Average
Flow (MGD)	All Year	--	--	--	--
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	All Year	--	--	25 mg/l 563 lb/d	40 mg/l 900 lb/d
Total Suspended Solids	All Year	--	--	30 mg/l 676 lb/d	45 mg/l 1014 lb/d
Total Phosphorus (as P)	All Year	--	--	1.0 mg/l	--
Dissolved Oxygen	All Year	4.0 mg/l	--	--	--
Fecal Coliform Bacteria	5/1-10/31 until 1/1/91	--	--	200/100 ml	400/100 ml
	All Year begin 1/1/91	--	--	200/100 ml	400/100 ml
Total Residual Chlorine	All Year until 1/1/91	--	0.5 mg/l	--	--
	All Year begin 1/1/91	--	0.036 mg/l	--	--
PCBs	All Year		monitoring only		
Mercury	All Year		monitoring only		
pH (standard units)	All Year	6.5	9.0	--	--

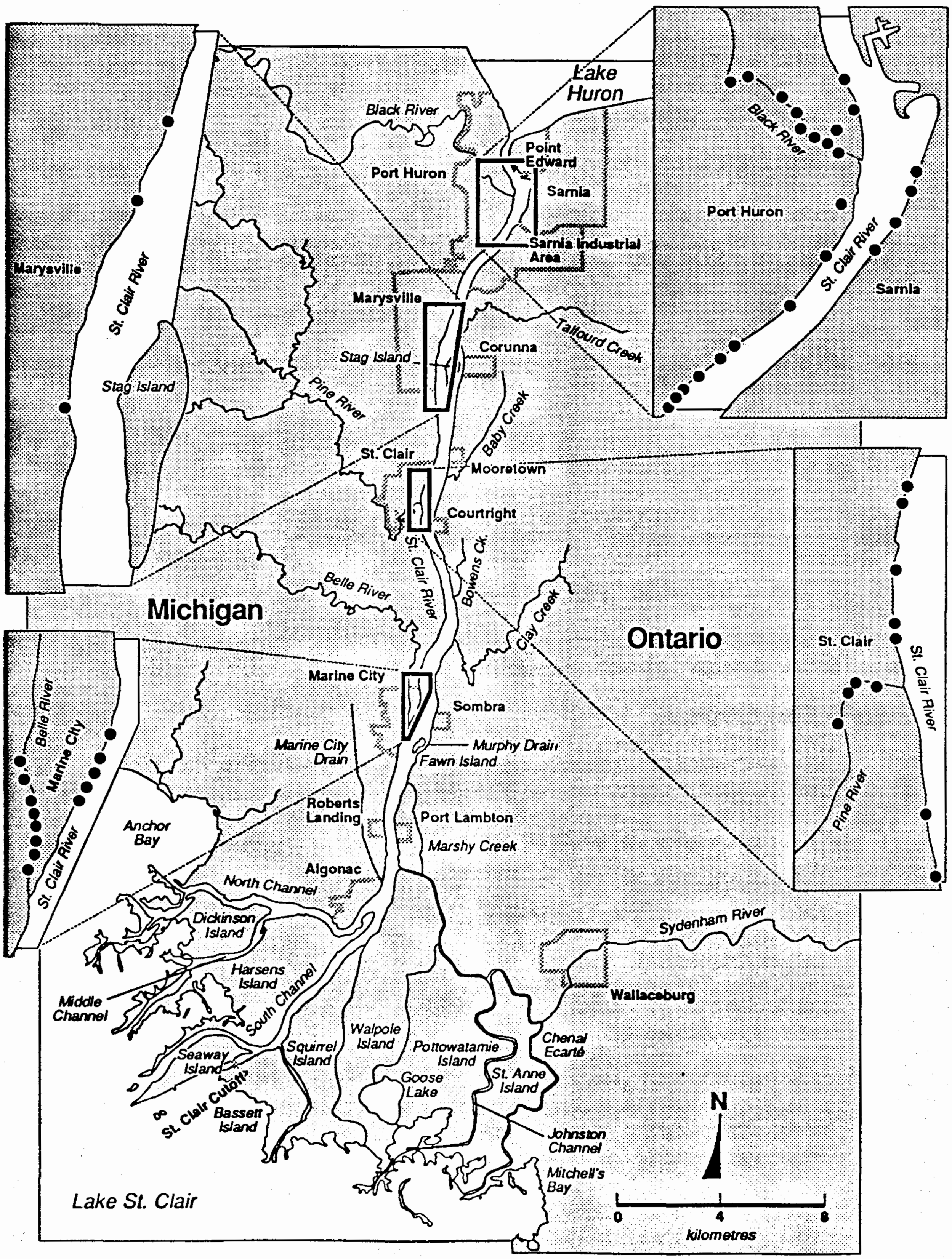
8.2.3.1 Ontario CSOs

The City of Sarnia is serviced with both separate and combined sewers. A program of sewer separation was begun in 1969 and, to date, approximately 50 percent of the originally combined sewer system has been separated (Paul Theil Associates 1988). Combined sewers serve approximately 540 ha (1,334 acres) of the City core area, consisting primarily of residential and commercial land use (Paul Theil Associates 1988). The CSOs discharge into an interceptor with four overflow structures to the St. Clair River (Marsalek and Ng 1989). These are discussed in more detail in Section 8.3.4.1. The overflow structures allow direct dumping of untreated combined sewage into the St. Clair River when the capacity of the interceptor is exceeded. In nonoverflow periods, the sewage is conducted to the sewage treatment plant.

Figure 8.3

St. Clair River Remedial Action Plan

The location of combined sewer overflow outfalls in Ontario and Michigan



● combined sewer overflow outfall

Bacterial loadings from Sarnia CSOs and St. Clair River nearshore bacterial water quality is currently being investigated under a joint Environment Canada/OMOE study. The study objectives are to determine the impacts of bacterial contamination on nearshore recreational activities and estimate bacterial loadings entering the St. Clair River including fate and transport mechanisms. A total of 20 dry events and 10 rain events have been sampled along with plume studies and time series analysis. Sample locations include influent and effluent from the Point Edward and Sarnia WPCPs, the Cromwell Street and Devine Street CSOs; and nine nearshore locations in the river between the Blue Water Bridge and Sunoco. Results are expected in late 1991.

8.2.3.2 Michigan CSOs

The Cities of Port Huron, Marysville, Marine City and St. Clair are serviced by combined storm and sanitary sewer systems (Figure 8.3). Combined sewer overflows (and stormwater discharges) are regulated in Michigan as point sources under the NPDES program. NPDES permits issued to Marine City, Marysville, Port Huron and St. Clair include specific requirements for CSO control programs. Specific CSO locations and permit requirements for each facility, including compliance schedules are provided in the NPDES permits (Appendix 8.1). The CSO regulatory program is discussed in general terms in Chapter 4.

8.2.4 Industrial Point Sources

Industrial effluents include final effluent from industrial wastewater treatment facilities, runoff from industrial sites, cooling water or process streams. They may be discharged to the river either directly or indirectly. Direct discharges are those which enter the river via a pipe, sewer or channel which services the plant site. Indirect discharges are those which enter a drain/ditch prior to entering the river. Loadings from direct and indirect industrial sources are considered for this section.

8.2.4.1 Ontario Industrial Point Sources

There are a total of 27 facilities representing four industrial sectors. The facilities and the number and nature of their discharges (direct-D, indirect-I) are listed below.

PETROLEUM REFINING:

- Esso Petroleum Canada (3-D)
- Novacor Chemicals Ltd., Corunna (formerly Petrosar Limited) (1-D)
- Shell Canada Products Ltd., Sarnia Manufacturing Centre (2-I via Allingham Drain and 5-I via Talfourd Creek)
- Suncor Inc., Sunoco Division (1-D)

ORGANIC CHEMICALS:

- AKZO Chemicals (2-I via Cole Drain)
- BASF Canada Inc. (2-I " " ")
- Chinook Chemicals (1-D)
- Dow Chemical Canada Inc. (7-D and 3-I)
- AMOCO (1-I via Cole Drain)
- DuPont Canada Inc. (1-D)
- Esso Chemical Canada (1-D)
- Ethyl Canada Inc., Corunna (1-D)
- Novacor Chemicals Ltd., Mooretown (1-D and 1-I via Baby Creek)
- Novacor Chemicals Ltd., Sarnia (formerly Polysar Ltd.) ⎤
- Polysar Rubber Corporation, Sarnia ⎦ (5-D and 6-I via Cole Drain)

INORGANIC CHEMICALS:
- Cabot Canada Inc. (1-I via Cole Drain)
- I.C.I. Nitrogen Products (1-D)
- Fiberglas Canada Inc. (1-I via Cole Drain)
- Partek Insulations Ltd. (3-I via Scott Road Drain)
- Welland Chemicals Ltd. (5-I)
- Linde-Mooretown (1-I)
- Linde-Sarnia (1-I via Cole Drain)
- Air Products (1-I via Cole Drain)
- Cardox (1-D)
- Liquid Carbonic (1-I)
- Standard Aggregate

THERMAL GENERATING:
- Ontario Hydro Lambton Thermal Generating Station (TGS) (3-D and 2-I)

One of the direct discharges identified above for Polysar/Novacor (Sarnia) is the outlet of the Cole Drain. This is because the outlet is on Polysar property. Loadings from that outlet incorporate all the upstream direct and indirect discharges, including direct discharge and seepage from several other industrial plant sites, landfills and surface runoff to the Cole Drain, the Scott Road Drain and the Perimeter Ditch for the Scott Road Landfills. The Cole Drain was formerly referred to as the "Township Ditch".

In the following sections, an overview of these industrial point sources describing the companies products, processes and wastewater treatment is included. Available 1984 through 1989 net discharge data (self-monitoring data as reported in the OMOE Industrial Dischargers Reports) are presented for regularly monitored parameters (industry-specific).

Net loadings are used as the basis of comparison for most years and most industries. In some cases, however, only gross loadings are reported. Gross and net loadings can not be compared to each other. Net loadings are determined by subtracting loadings in the intake water from those of the outfall in order to determine only the loads from the facility. Gross discharge data (i.e., total of intake and outfall) are the only data available for 1989 for the petroleum sector and for all years at I.C.I., Ethyl, Novacor Chemicals and Fiberglas Canada. The 1989 petroleum sector data for regularly monitored parameters are not used with the exception of the twelve month MISA Monitoring study described at the end of the Petroleum Sector discussion.

Industry-specific effluent guidelines are also indicated, many of which have been determined by Certificates of Approval (CofA). The first page of the CofA for industrial facilities of the St. Clair River are provided in Appendix 8.2 for illustrative purposes. Each CofA is maintained as a discreet document and a complete listing is not currently available.

Loadings, as expressed in kg/d based on annual averages, are utilized in the following discussion for comparative purposes. Data from the Ontario Industrial Direct Discharges Reports are annual averages (monthly averages are provided in each report) whereas data from specific surveys are based on sampling periods ranging from 3 to 6 days (UGLCCS 1988) to 12 months (MISA Monitoring Study for the Petroleum Sector).

Toxicity testing is conducted by OMOE based on a static lethality test using rainbow trout (OMOE 1989b). The test measures the concentration of effluent that will kill 50 percent of the test fish in four days (LC50, 96hr). The Federal toxicity tests are based on 24 hour and/or 96 hour static lethality tests using rainbow trout. More than 50 percent mortality is considered a violation of the guidelines (Environmental Protection 1989). Specific results for individual facilities are only available for the petroleum sector.

8.2.4.1.1 Petroleum Sector

Descriptions of facilities representing the petroleum sector are based on their 1991 status.

Esso Petroleum Canada, Sarnia

The Esso Petroleum refinery in Sarnia was started in 1871. Its present crude oil capacity is 134,000 barrels per day. The refinery produces a complex combination of fuel products, packaging, lubricating oil, and petrochemical operations.

The refinery is divided into fuel and lubricating oil processing areas. Fuel processing includes atmospheric and vacuum distillation, fluid catalytic cracking, hydrocracking, fluid coking, alkylation, naptha reforming, hydrogen treating and light hydrocarbon distillation and treating facilities, and sulphur units. These processes are integrated with the Esso Chemical petrochemical operations. Lubricating oil processing facilities include phenol treating, solvent dewaxing and hydrogen treating of lube oils and waxes (OMOE 1990b).

The refinery has segregated systems for treating once-through cooling water and oil contact water. Once-through cooling water is treated in four parallel API separators for solids and oil removal prior to discharge. Oil contact water consists of process wastewater, stormwater, ship's ballast, tank water draw-off, and landfarm leachate. The wastewater treatment sequence is comprised of API oil/water separation, sand/anthracite filtration, biological oxidation and clarification.

Sour water is steam-stripped to remove sulphides and ammonia and then transferred to a biological oxidation (BIOX) unit. The effluent is then combined with the filtered oil contact water and transferred to another biological oxidation unit.

Stormwater storage tankage is provided, which is sufficient to contain the runoff from a one in 10 year storm event. This set-up prevents overloading of the treatment facilities.

An active source control program identifies and corrects leaks or other problems before they can adversely affect the operation of the treatment plant (OMOE 1988a).

Petroleum refineries in Ontario are subject to the Federal "Petroleum Refinery Effluent Regulations and Guidelines (January 1974)" which stipulate baseline standards based on best practicable technology. Limitations for oil and grease, total suspended solids, ammonia-nitrogen and sulphide are based on loadings per unit of raw material (pounds per thousand barrels). Toxicity and pH are also regulated. Esso Petroleum, as an existing refinery at the time the Regulations and Guidelines were promulgated, is subject to the Guidelines (OMOE 1990b).

Federal Effluent Guidelines

Ontario's "Liquid Effluent Guidelines for the Petroleum Refining Industry" set concentration-based effluent quality objectives for oil and grease, phenols, sulphides, sulphide, suspended solids, ammonia-nitrogen, COD, and pH (Petroleum Refinery Point Source Task Force 1982). Ontario's 20 $\mu g/L$ objective for total phenols has proven to be much more stringent than the Federal loading requirement (OMOE 1990b).

In 1984, Esso Petroleum's combined effluent was in compliance with all Federal guidelines for phenols, suspended solids, ammonia-nitrogen, sulphide and pH. Exceedences were recorded for oil and grease and suspended solids during the first two months of 1984. Noncompliance was due to two incidents:

1. A heavier-than-water oily waste entered the process sewer and passed through the oily water separators; and

2. Loss of material in the dual media filters resulted in reduced efficiency.

Remedial measures have since been implemented to prevent a reoccurrence of these incidents (as required under the *Environmental Protection Act* 1987). In 1987, Esso Petroleum (combined effluent) was in full compliance for oil and grease, phenols, sulphides, ammonia-nitrogen, and suspended solids (Environmental Protection 1989). Monthly toxicity tests revealed no fish mortality (total of 12-24 hour tests).

Provincial Effluent Guidelines

Provincial monitoring data for Esso Petroleum are shown in Table 8.11. These data include the annual averages and the number of monthly exceedences in parenthesis, for the monitored parameters from 1984 through 1988.

Table 8.11 Annual average net loadings in kg/day and exceedences (# of months) of parameters under control at Esso Petroleum Canada, 1984 through 1988[1] (OMOE 1990b, 1989b, 1988c, 1987b).

Parameter	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	217.01	207.72	210.42	210	215
Total NH^3-N (kg/day)	7.02 (0)	15.41 (0)	15.26 (0)	24 (0)	56
Total Phenols (kg/day)	0.13 (0)	0.48 (0)	0.03 (0)	0.70 (0)	0.60
Total Suspended Solids (kg/day)	0*	32.69 (0)	29.92 (0)	418 (0)	290
Oil and Grease (kg/day)	30.6 (0)	7.91 (0)	4.17 (0)	113 (0)	176
Total Organic Carbon (TOC) (kg/day)	67.60	198.61	61.08	na	na

0* Indicates intake exceeded discharge loading.
na = Data not available.

[1] 1989 data are monitored under MISA as gross loadings and, hence, are not comparable to the earlier data.
[2] 1988 data from OMOE 1989b
[3] 1987 data from OMOE 1988c
[4] 1986 data from OMOE 1987b
[5] 1985 data from OMOE files 1990b
[6] 1984 data from OMOE files 1990b

Table 8.11 shows that from 1984 to 1988, Esso Petroleum was in full compliance with provincial guidelines for ammonia-nitrogen, phenols, suspended solids, and oil and grease. Compliance was determined on an annual average basis for 1984, and on a monthly basis for 1985 through 1988. Note that guidelines are tied to the total flow from the facility, as opposed to individual sewers or the process effluent itself. The loadings of ammonia-nitrogen, total phenols, total suspended solids, and oil and grease decreased substantially during

1986-88 as compared to 1984-85. The period of record for total organic carbon (an indirect measure of organic contaminants) is not sufficient to establish trends.

Effluent from the Biological Oxidation (BIOX) Plant was found to be non-acutely lethal to trout in one bioassay conducted during 1988 (OMOE 1989b).

UGLCCS Survey

The Esso Petroleum activated sludge plant (BIOX) effluent was sampled over a five day period from October 15 to 20, 1986, as part of the UGLCCS (1988). The survey results are shown in Table 8.12.

Table 8.12 Results of the UGLCCS (1988) point source survey conducted in 1986 at Esso Petroleum showing effluent concentrations in comparison to the Ontario Effluent Objectives.

Parameter	Ontario Effluent Objectives (mg/L)	UGLCCS Survey Range (mg/L)
Oil and Grease	10	0.3 - 3.9
Total Phenols	0.020	0.006 - 0.0065
Suspended Solids	15	3 - 12
Ammonia-Nitrogen	10	ND - 1.1
pH	5.5 - 9.5	6.8 - 7.0
Total Chromium	1.0	ND - 0.003
Total Copper	1.0	0.009 - 0.015
Total Nickel	1.0	0.008 - 0.014
Total Lead	1.0	ND
Total Zinc	1.0	0.013 - 0.028

Minimum Detection Limits: Ammonia-Nitrogen 0.1 mg/L
Metals 0.005 mg/L

The effluent complied with all OMOE concentration-based objectives, however, when compared to the 1986 self-monitoring data, results were representative for the month of October but not necessarily indicative of annual average conditions (OMOE 1990b).

Novacor Chemicals (Canada) Ltd, Corunna

Novacor Chemicals (Canada) Ltd. petrochemical refinery complex in Corunna commenced operation in 1978 as Petrosar Limited. It processes crude oil, condensate and natural gas liquids for the production of 1.3 million tonnes (1.43 tons) per year of primary petrochemicals (ethylene, propylene, butadiene, iso-butylene, n-butylene, benzene and toluene/xylene).

Naptha, heavy atmospheric gas oil, vacuum gas oil, No. 2 fuel oil ethane, propane and butane are all produced as intermediate or final products. Whether they are further processed (i.e., cracked) or sold depends upon market demand and economics. The main processes in the complex are atmospheric and vacuum distillation, olefin cracking and separation, gasoline hydrotreating and aromatic extraction (OMOE 1988a).

The Novacor Chemicals plant uses a recirculating cooling water system. The wastewater is segregated into four types: chemical or process wastewater, oily water, stormwater, and sanitary wastewater.

Spent caustic is neutralized before combining with sour wastewaters which are subsequently passed through a sour water stripper. This pretreated wastewater combines with other process water and passes through a conventional refinery treatment process composed of: oil separator, equalization, dissolved oil floatation, biological treatment (activated sludge) and clarification. Oily water and contaminated stormwater pass through a parallel system of oily water separation and equalization before discharging into the biological treatment plant. The clarifier effluent discharges through activated carbon when necessary, or bypasses the carbon treatment and discharges directly to one of the two final holding ponds (in parallel). Recycling of process or oily effluent for retreatment is possible after the equalization ponds and following clarification (OMOE 1990b).

Cooling tower blowdown discharges directly to the final holding ponds. Sanitary wastewater is treated on-site in a package biological treatment plant before discharging to the holding ponds. The holding pond discharge to the river can and has been shut off completely when the final effluent is not in compliance with effluent limitations (OMOE 1990b).

Uncontaminated runoff is directed to a stormwater holding pond which doubles as a fire pond. Periodically, part of the pond contents may be discharged to Baby Creek, a tributary of the St. Clair River, to control the water level in the pond.

Federal Effluent Guidelines

Novacor Chemicals is subject to the Federal "Petroleum Refinery Effluent Regulations and Guidelines" and Ontario's "Liquid Effluent Guidelines for the Petroleum Refining Industry" both of which have been previously outlined (see Esso Petroleum).

Novacor Chemicals, Corunna was in full compliance with Federal regulations in 1984 and 1987 for oil and grease, suspended solids, phenols, ammonia-nitrogen and pH. The combined effluent was found to be non lethal to fish based on 12 monthly tests (4-24 hr tests and 6-96 hr tests) (Environmental Protection 1987).

Provincial Effluent Guidelines

Loading data for regularly-monitored parameters at Novacor Chemicals, Corunna are shown in Table 8.13. These data include the annual averages with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1989.

For 1984 and 1985, Novacor Chemicals was in compliance with all provincial requirements for ammonia-nitrogen, suspended solids, and oil and grease (Table 8.13). The annual average phenol loading for 1984 exceeded the total phenols limit. In 1985, compliance was assessed on a monthly basis and Novacor Chemicals exceeded the limit during the first three months of the year. The company was able to improve source separation and optimize treatment in order to meet the effluent requirement (OMOE 1990b). Novacor Chemicals, Corunna has been in full compliance with all regularly-monitored parameters from April, 1985 through 1988 (Table 8.13). The annual average loadings for this facility have decreased over the period of record, particularly in 1987 and 1988, for ammonia-nitrogen, total phenols, suspended solids, oil and grease.

Table 8.13 Annual average <u>net</u> loadings in kg/day and exceedences (# of months) of parameters under control at Novacor Chemicals (Canada) Ltd, Corunna, 1984 through 1988[1] (OMOE 1990b, 1989b, 1988c and 1987b).

Parameter	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	4.85	6.34	6.47	6.6	6.6
Total NH^3-N (kg/day)	5.17 (0)	13.92 (0)	15.26 (0)	14.5 (0)	19.5
Total Phenols (kg/day)	0.023 (0)	0.032 (0)	0.03 (0)	0.11 (3)	0.43 (All samples)
Total Suspended Solids (kg/day)	21.7 (0)	21.42 (0)	29.92 (0)	43.7 (0)	70.2
Oil and Grease (kg/day)	1.25 (0)	2.58 (0)	4.17 (0)	11.1 (0)	10.4
Total Organic Carbon (TOC) (kg/day)	34.4	29.67	61.08	na	na

na = Data not available.
1 1989 data are gross and, hence, not comparable to the earlier data
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

Novacor Chemicals must also comply with specific requirements of their CofA. Landfarm leachate (CofA # A031821) must not exceed the following:

Oil and Grease	10 mg/L
Phenols	0.020 mg/L
Suspended Solids	15 mg/L
Ammonium Nitrogen	10 mg/L
COD	200 mg/L
pH	5.5 to 9.5
Chromium	1 mg/L
Copper	1 mg/L
Nickel	1 mg/L
Lead	1 mg/L
Zinc	1 mg/L

<u>UGLCCS Survey</u>

Effluent concentration data for 10 parameters analyzed during the UGLCCS (1988) point source survey are provided in Table 8.14. Final effluent was surveyed over a 5-day period from November 25 to 30, 1986. Relatively high concentrations (258 to 567 μg/L) of total chromium were detected during this survey at Novacor Chemicals. Although within the Ontario Effluent Objectives (Table 8.14), Novacor has instituted a waste treatment change since the UGLCCS survey incorporating organic phosphate treatment of the cooling water resulting in the elimination of elevated chromium discharges. The Novacor Chemicals final effluent complied with all OMOE concentration-based objectives.

Table 8.14 Results of the UGLCCS (1988) point source survey conducted in 1986 for Novacor Chemicals (Canada) Ltd, Corunna showing effluent concentrations in comparison to Ontario Effluent Objectives.

Parameter	Ontario Effluent Objectives (mg/L)	UGLCCS Survey Range (mg/L)
Oil and Grease	10	2.8 - 5.3
Total Phenols	0.020	0.009 - 0.011
Suspended Solids	15	5 - 10
Ammonia-Nitrogen	10	0.7 - 1.4
pH	5.5 - 9.5	7.1 - 7.5
Total Chromium	1.0	0.258 - 0.567
Total Copper	1.0	ND
Total Nickel	1.0	ND - 0.015
Total Lead	1.0	ND
Total Zinc	1.0	0.093 - 0.727

Minimum Detection Limits: Metals 0.005 mg/L

Sarnia Manufacturing Centre, Shell Canada Products Limited

Shell's Sarnia Manufacturing Centre (SMC) is located on the St. Clair River south of Sarnia, at Corunna, Ontario. It comprises an oil refinery built in 1952 and a chemical plant built in 1979.

The refinery has a crude oil handling capacity of 11,800 m_3/day. In addition to gasoline, diesel, furnace fuel and bunker fuel, the products include pure chemicals (benzene, toluene, xylene and sulphur) as well as hydrocarbon solvents.

The chemical plant is made up of two facilities, one for manufacturing polypropylene plastic, the other for manufacturing isopropyl alcohol. The capacity of the isopropyl alcohol plant is 92,500 tonnes/year (101,935 tons/year) and the capacity of the polypropylene plant is 170,000 tonnes/year (187,340 tons/year).

The major processes at this refinery/chemical plant complex include: distillation, catalytic cracking, thermal cracking, hydrocracking, catalytic reforming, solvent hydrogeneration, aromatics extraction and hydrotreating (refinery); and polymerization and hydrolysis/dehydration (chemical plant). All of the wastewater is treated in the wastewater treatment facility.

Shell takes about 200,000 to 300,000 m^3 (52 to 78 X 10^6 U.S. gal) of water from the St. Clair River each day. The largest portion (100,000 to 200,000 m^3/26 to 52 X 10^6 U.S. gal) of this water is once-through cooling water. It is used in coolers where the water pressure is higher than the product pressure and, thus, is not normally contaminated. Once-through cooling water is discharged into Talfourd Creek. Potentially contaminated cooling water (water pressure equal to or less than product pressure) is combined with boiler blowdown and, occasionally, process effluent before discharge through three potentially oily water separators.

Two of the separators discharge into Talfourd Creek. Discharge from the third separator combines with the uncontaminated cooling water before discharging into the creek.

Sour phenolic wastewaters are pretreated through a sour water stripper before combining with other process water, storage tank bottoms, desalter water, laboratory wastewaters, ballast water, contaminated stormwater and landfarm leachate. The combined process effluent flows to an oily water separator for gross oil removal. Stormwater which is potentially contaminated is combined with landfarm leachate and flows through either a separate oil water separator or into a stormwater holding pond. The stormwater separator effluent combines with the process separator discharge and discharges to the dissolved air floatation unit which removes dispersed oil. Water stored in the stormwater holding pond is either processed in the dissolved air floatation unit or discharged to Talfourd Creek if it meets the CofA criteria.

The effluent from the dissolved air floatation unit is combined with pretreated effluent from the chemical plant and then discharged to an equalization basin which has approximately a 12 hour retention time. The discharge combines with the refinery septic tank overflow and flows to the activated sludge plant for biological treatment. After clarification, the treated effluent normally combines with POW separator effluent before discharge to Talfourd Creek.

At the chemical plant, process water, cooling tower blowdown, tank bottoms, water from tank farm dyked areas, laboratory wastewater and process pad stormwater combine with contaminated stormwater and discharge to a tilted plate interceptor for solids removal. The effluent next flows to an equalization basin which discharges to the refinery and joins the dissolved air floatation effluent. Potentially contaminated stormwater is held in a large storage pond which is manually discharged to Talfourd Creek if the quality of the runoff is acceptable. Otherwise, this stormwater flows into the equalization basin for treatment.

Federal Effluent Guidelines

Shell Canada Products Limited is subject to the Federal "Petroleum Refinery Effluent Regulations and Guidelines" and Ontario's "Liquid Effluent Guidelines for the Petroleum Refining Industry" both of which have been previously outlined (see Esso Petroleum).

In 1987, there were no exceedences of ammonia-nitrogen, phenols or pH. Suspended solids exceeded the monthly guideline six times. The oil and grease monthly guideline was exceeded only once. Four combined effluent toxicity tests (24 hour) showed no mortality (Environmental Protection 1989).

Provincial Effluent Guidelines

Loading data for regularly-monitored parameters at Shell Canada Products are shown in Table 8.15. These data include the annual averages and number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1988.

In 1984 Shell Canada Products was in compliance with Federal Regulation and Guideline limits (compliance based on an annual average) for oil and grease, suspended solids, phenols, ammonia-nitrogen, chemical oxygen demand, pH and metals (chromium, copper, nickel, lead and zinc). However, oil and grease and total suspended solids exhibited average monthly exceedences of their respective provincial requirements (Table 8.15). Oil and grease exceeded the monthly average limit once, while there were 5 monthly average exceedences for suspended solids. However, 6 months of the year were determined to have negative net loadings for suspended solids which seems to be a function of including once-through cooling water results in the loading calculation (OMOE 1990b). This may also account for the suspended solid exceedences because the nearshore zone of the St. Clair River becomes highly turbid especially after storms (OMOE 1990b).

Table 8.15 Annual average net loadings in kg/day and exceedences (# of months) of parameters under control at Shell Canada Products, Corunna, 1984 through 1988 (OMOE 1989b, 1988c and 1987b).

Parameter	1988[1]	1987[2]	1986[3]	1985[4]	1984[5]
Flow (1000 m^3/day)	230.19	251.00	222.89	226.00	235.00
Total NH^3-N (kg/day)	16.57 (0)	7.56 (0)	2.73 (0)	6.50 (0)	4.80
Total Phenols (kg/day)	0.10 (0)	0.11 (0)	0.18 (0)	0.35 (0)	0.42
Total Suspended Solids (kg/day)	210.00 (0)	562.70 (0)	371.10 (0)	767.00 (0)	0* (5)
Oil and Grease (kg/day)	8.15 (0)	136.98 (0)	118.70 (0)	117.00 (0)	88.00 (1)
Total Organic Carbon (TOC) (kg/day)	249.00	718.00	296.69	na	na

0* Indicates intake exceeded discharge loading.
na = Data not available.

1 1988 data from OMOE 1989b
2 1987 data from OMOE 1988c
3 1986 data from OMOE 1987b
4 1985 data from OMOE files 1990b
5 1984 data from OMOE files 1990b

Table 8.15 shows that Shell Canada Products Limited has been in 100 percent compliance with its provincial requirements for ammonia-nitrogen, phenols, suspended solids, and oil and grease from 1985 through 1988. There is no clear trend for ammonia-nitrogen, oil and grease or total organic carbon (an indirect measure of organic contaminants) over the period of record, however, total phenols and suspended solids were all much lower in 1988 than in previous years.

Shell Canada must also meet effluent-specific guidelines specified in two CofA. Biotreater effluent (CofA # 4-0093-88-06) must not exceed 100 mg/L volatile suspended solids; and 0.13 mg/L phenols. Stormwater effluent (CofA # 4-0048-87-006) must not exceed:

Ammonia	10 mg/L
Oil and Grease	15 mg/L
Phenols	0.02 mg/L
Volatile Suspended Solids	15 mg/L

One trout bioassay conducted in 1988 indicated that the total effluent was non-acutely lethal to the test fish (OMOE 1989b).

Suncor Inc., Sarnia

The Suncor Sarnia refinery was built in 1953. The refinery is located on the St. Clair River immediately adjacent to, and downstream from, the major Sarnia petrochemical complexes.

During 1987, approximately 9,000 m^3/d (2.34 X 10^6 U.S. gal/d) of crude oil were processed into motor gasolines, light and heavy fuels, light aromatic products, liquified gases and solid sulphur.

The refinery processes include atmospheric and vacuum distillation, catalytic cracking, hydrocracking, catalytic reforming, and BTX (benzene, toluene, xylene) aromatic extraction, as well as various strippers, hydrotreaters and scrubbers.

All gas streams containing hydrogen sulphide (H_2S) are collected and approximately 24,000 kg/d of elemental sulphur are recovered in a Claus sulphur unit.

Suncor has a segregated sewer system for process water, contaminated or potentially contaminated stormwater and once-through cooling water. All streams combine prior to discharge via a single shore-based sewer. Once-through cooling water passes through an oily water separator before discharge.

Sour wastewater is pre-treated by stripping to remove hydrogen sulphide (see above) and ammonia. Spent caustic is also pre-treated, first by neutralization and subsequently stripped to remove hydrogen sulphide. Process water, composed of pre-treated effluents, laboratory wastewaters, etc., discharge to an oily water separator for gross oil removal. Ballast water from ships is stored and tested on site. Its oil content determines whether it is discharged to the process separator or to the stormwater system.

Process water next passes through a vertical tube separator for further oil removal prior to discharge into an equalization basin. The equalization basin discharges to an induced oil floatation unit to remove fine oil droplets and then to the first of two activated sludge cells (in series). Sanitary wastewater from the site also discharges to the activated sludge plant.

Cooling tower blowdown as well as contaminated and potentially contaminated stormwater discharge to an oily water separator and next to an induced air floatation unit. An overflow weir between the separator and the induced air floatation unit allows excessive stormwater flows to be directed to one of two impounding basins for storage and subsequent treatment under more normal hydraulic conditions. The pre-treated stormwater then discharges to the second aeration cell at the activated sludge plant.

The combined, biologically treated wastewater passes through two clarifiers in parallel before discharging to a second impounding basin. In the event of a treatment plant upset, the impounding basin contents can be retreated after being pumped back to the equalization basin, or to the process oily water separator.

The impounding basin effluent discharges to the cooling water sewer and the combined effluent discharges to the St. Clair River. The river water intake is located upstream of the Suncor discharge but due to Suncor's location downstream of Dow Chemical, Polysar and the Cole Drain, it sometimes contains trace contaminants.

Suncor's landfarm (biotreatment sludge degradation) is located on the East Tank Farm property. Landfarm leachate is stored and hauled by tank trucks to the wastewater treatment facility.

Federal Effluent Guidelines

Suncor is subject to the Federal "Petroleum Refinery Effluent Regulations and Guidelines" and Ontario's "Liquid Effluent Guidelines for the Petroleum Refining Industry" both of which have been previously outlined (see Esso Petroleum).

During 1984, Suncor was in compliance with the Federal Guidelines for oil and grease, phenols, sulphide, ammonia-nitrogen, and pH. The monthly average limit suspended solids was exceeded for one month. This exceedence was partly attributed to a new hydrocracking unit which was brought on line in 1984

(OMOE 1990b). The wastewater treatment system was expanded and upgraded during 1985 and 1986, however, the monthly guideline for suspended solids was also exceeded once during 1987. Ammonia-nitrogen also exceeded the monthly guideline once in 1987. There were no monthly exceedences of oil and grease, phenols, sulphides or pH. Monthly 24 hour and 96 hour toxicity tests using combined effluent revealed no trout mortality (Environmental Protection 1989).

Provincial Effluent Guidelines

Loading data for provincial regularly-monitored parameters at Suncor Inc. are shown in Table 8.16. These data include the annual averages and number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1988.

Table 8.16 Annual average net loadings in kg/day and exceedences (# of months) of parameters under control at Suncor Inc., Sarnia, 1984 through 1988[1] (OMOE 1990b, 1989b, 1988c and 1987b).

Parameter	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	96.66	96.53	97.01	101	110
Total NH^3-N (kg/day)	17.50 (0)	42.59 (0)	33.25 (0)	23.30 (0)	31.10 (0)
Total Phenols (kg/day)	0.19 (0)	0.24 (0)	0.35(0)	0.67 (1)	1.08 (1)
Total Suspended Solids (kg/day)	219.0 (0)	205.6 (0)	362.8 (0)	222.0 (0)	255.0 (0)
Oil and Grease (kg/day)	45.60 (0)	69.18 (0)	72.83 (0)	44.10 (0)	94.30 (0)
Total Organic Carbon (TOC) (kg/day)	157.00	237.22	411.91	na	na

na = Data not available.

1 1989 data are gross and, hence, not comparable to the earlier data
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

Table 8.16 shows that Suncor Inc. Sarnia has been in full compliance with provincial requirements since 1984 for ammonia-nitrogen, suspended solids, and oil and grease. Total phenol loadings exceeded the guideline only twice between 1984 and 1988. These occurred during one month in each of 1984 and 1985.

This parameter has not exceeded the guideline in the monthly monitoring data since 1985, however, the 1986 short term survey (3 to 6 day) conducted by UGLCCS (1988) identified this parameter as exceeding the Ontario Industrial Discharge Objective (20 μg/L). The data in Table 8.16 indicate that the lowest loadings for total organic carbon, oil and grease, suspended solids, total phenols and ammonia-nitrogen generally occurred in 1987 and 1988, subsequent to the treatment plant upgrading.

The process water effluent was found to be non-acutely lethal to trout in one bioassay conducted during 1988 (OMOE 1989b).

8.2.4.1.2 MISA Monitoring Study (1988-89), Petroleum Sector

The results of the 12 month (December 1988 to November 1989) MISA Monitoring Study for the Petroleum Sector includes data for the four facilities in the Sarnia area (Table 8.17). Total suspended solids, phenolics and oil and grease (solvent extractables) are the only parameters which are similar to those analyzed by either the self-monitoring data (1984-1988) or the UGLCCS data (1986). The MISA data, however are gross loadings, not net loadings and, hence are not directly comparable to the 1984-1988 data presented above nor the UGLCCS data. The results of the petroleum monitoring are presented Chapman and Loo-Sy (1990) as well as in two separate 6-month reports by OMOE (OMOE 1989f and 1990d).

Table 8.17 MISA monitoring gross[1] loadings data (kg/d) for the Sarnia area petroleum refineries, December 1, 1988 to November 30, 1989 (Chapman and Loo-Sy 1990).

Facility	Avg Flow Rate (1000 m^3/day)[2]	Total Suspended Solids (TSS)	Volatile Suspended Solids (VSS)	Phenols	Oil and Grease	Sulphide	Sum BTXE[3]	PCBs	Zinc[5]
Esso Petroleum	210.3	407.06	210.8	0.09	-6.01[4]	3.04	0.75	ND	0.49
Novacor Chemicals (formerly Petrosar)	5.8	172.29	64.74	0.04	11.64	1.52	0.00	ND	2.81
Shell Canada Products	173.7	469.77	414.76	0.28	30.63	-1.49	4.04	ND	2.06
Suncor Inc, Sunoco Div.	90.0	-98.97	29.7	0.05	-16.21	0.15	0.23	ND	0.46

ND = below method detection limit.

[1] These data are based on gross loadings for process streams, farm leachate and stormwater runoff but net loadings were calculated for cooling water discharge. Hence these data are not directly comparable to the 1984 to 1989 data presented elsewhere.

[2] Average total discharge flow rates calculated from continuous discharges plus intermittent discharges (average discharge per event). Includes process effluent, once-through cooling water, landfarm leachate, storm water and emergency overflows.

[3] BTXE represents combined value for benzene, toluene, xylenes and ethylbenzene.

[4] Negative values result from the Net Cooling Discharge Rate whereby the influent concentration was higher than the effluent concentration.

Loadings from the four petroleum refineries at Sarnia for each of the three parameters (TSS, phenolics and oil and grease) are generally in the same range as the net self-monitoring data for 1988 presented for each facility. The 1988/89 gross loadings of these parameters to the St. Clair (Table 8.17) are low relative to those identified for the major contributors by the UGLCCS (1988) based on 1986 net data. In particular, the loading of total phenolics from Suncor during 1988/89 (0.05 kg/d) tends to confirm the trend toward decreasing loadings compared to 1986 (0.932 kg/d) and 1988 (0.188 kg/d), especially given that the gross data may over-estimate the actual loading from the facility.

All the refineries provide secondary treatment of process wastewater. During the monitoring period of this study they were found to be capable of achieving U.S. EPA BPT performance requirements for end-of-pipe treatment for phenolics (100 μg/L), oil and grease (5 mg/L), sulphides (0.1 mg/L) and chromium (250 μg/L) in process effluents. The Sunoco refinery also met the requirement for TSS (10 mg/L).

Mean average concentrations in process wastewater at all four refineries also met the OMOE Objectives for Industrial Waste Discharges for pH (5.5 to 9.5), oil and grease (10 mg/L), phenolics (20 μg/L), chromium (1000 μg/L) and zinc (1000 μg/L). Only Esso and Suncor met the OMOE Objective for TSS (15 mg/L).

In addition to these parameters, the Suncor effluent also had an average heptadibenzodioxin concentration of 0.00004 μg/L during the second 6-month sampling period (OMOE 1990d). This value is below the OMOE Interim Petroleum Effluent Guideline of 0.000015 2,3,7,8-TCDD toxic equivalent. Dioxins were not detected at other facilities.

A total of 24 toxicity tests were carried out for each facility. These included separate LC50 tests for toxicity to rainbow trout and *Daphnia magna* (1 test per month for each). Process and cooling water effluent from all four Sarnia area refineries passed all rainbow trout and *Daphnia magna* tests (OMOE 1989f and 1990d). Process effluent concentrations for phosphorus and volatile organics including benzene, toluene, xylenes and ethylbenzene (BTXE) were highest for Esso, Sarnia in comparison to all seven Ontario refineries.

Novacor's average process effluent concentrations for sulphides and chromium were the highest of all Ontario refineries. However, the level of sulphide concentrations dropped during the monitoring period from about 0.39 mg/L during the first six months to 0.18 mg/L during the last six months. The use of chromium and zinc as cooling water additives was phased out by the refinery in September 1989. Consequently, chromium concentrations dropped from 300 μg/L to less than 50 μg/L and zinc concentrations dropped from 600 μg/L to less than 250 μg/L from the beginning to the end of the monitoring period.

Shell and Suncor had higher average concentrations of benzene, ethylbenzene, toluene, o-xylene, and m+p-xylenes in their cooling water discharges than in their process effluent. Esso also had higher average concentrations of benzene and toluene in cooling water discharges. Other parameters tended to be lower in concentration in cooling water than in process effluent.

A total of 109 organic contaminants including halogenated, non-halogenated and water soluble volatiles; base neutral extractables; acid extractables (phenolics); neutral chlorinated extractables; and chlorinated p-dioxins and dibenzofurans in process effluents were also analyzed (Chapman and Loo-Sy 1990). The frequency of detection of these parameters was extremely low at all Sarnia area facilities. The most notable parameters detected in process effluent but not in intake waters were chloroform - 16 percent at Esso and 50 percent at Suncor; methylene chloride - 25 percent at Nova Petrochemicals; 3 phthalate esters - 16 percent to 41 percent at Nova Petrochemicals; and heptachlorinated dibenzo-p-dioxin - 50 percent (1 of 2 samples) at Suncor. When translated into 2,3,7,8 total chlorinated dibenzo-p-dioxin (TCDD) using the 1989 International Toxicity Equivalency Factors, the effluent contained less than 15 parts per quadrillion of 2,3,7,8-TCDD (OMOE interim guideline for petroleum effluent).

8.2.4.1.3 Organic Chemicals Sector

Descriptions of facilities representing the organic chemicals sector are based on their 1991 status.

AKZO Chemicals Ltd., Sarnia

AKZO Chemicals Ltd. is a specialty chemical plant manufacturing the active ingredients used in fabric softeners and personal care products. Surface runoff discharges to the Cole Drain, as does the once-through cooling water flow of 982 m^3/d (25,532 U.S. gal/d), hence, loadings from this facility are included with data for the Cole Drain (see below). Process wastewater, averaging 111.3 m^3/d (28,938 U.S. gal/d) is pumped through a transfer line to the Polysar Rubber Corporation Biological Oxidation Wastewater Treatment (BIOX) plant for treatment.

BASF Canada Inc., Sarnia

BASF Canada Inc. is a liquid dispersions manufacturing plant producing dispersions used in the paper, textile, flooring and adhesive industry. Surface runoff discharges to the Cole Drain, as does the once-through cooling water flow of approximately 26,185 m^3/d (6.8 X 10^6 U.S. gal/d) (loadings included with those for Cole Drain). Process wastewater, which consists mainly of latex effluent and styrene condensate, is pumped through transfer lines to the Polysar Rubber Corporation wastewater treatment system which discharges effluent to the Polysar Rubber Corporation BIOX plant. The waste latex effluent flow is approximately 157 m^3/d (40,820 U.S. gal/d). The Styrene condensate flow is approximately 45 m^3/d (11,700 U.S. gal/d).

Chinook Chemicals Company, Sombra

The Chinook Chemicals plant near Sombra, Ontario is Canada's only methylamine plant. Methylamine derivatives, choline chloride and dimethyl formamide are also manufactured.

Stormwater runoff from the process and storage tank areas is routed to a holding pond for storage. This is the only water that discharges into the holding pond. During the period late April to October, and depending on the weather conditions, the pond contents are spray irrigated on adjacent land. The drainage from the spray irrigation field is collected and discharged to the St. Clair River via a submerged 2 inch poly pipe.

The other discharges from the site are cooling tower blowdown, boiler water blowdown as well as a maintained flow of river water to supplement the blowdown flows and prevent winter freezing.

The total discharge from the facility is approximately 197 X m^3/d (51,220 U.S. gal/d). Chinook Chemicals is conducting the required MISA sampling and analysis of discharge waters for pH, dissolved organic carbon (DOC) and specific conductance (OMOE 1990b).

Dow Chemical Canada Inc., Sarnia Division

The Dow manufacturing complex is situated along the St. Clair River in the heart of "Chemical Valley". Operations first began at the site in 1942 when the Canadian Government asked the Dow Chemical Company to build a plant for the production of synthetic rubber.

After the war, Dow began to diversify into other product areas. Today the site occupies 185 hectares and employs about 1300 people in 12 individual plants and 1 power plant.

The major products manufactured at the site include vinyl chloride monomer, propylene oxide, propylene glycols, polyglycols, chlorine, caustic soda, anhydrous hydrochloric acid, styrene, polystyrene, latex, ethylbenzene, chlorinated solvents, epoxy resins, and high density and low density polyethylene.

Effluents from Dow Chemical are discharged through seven outfalls to the St. Clair River. Two water intakes are located downstream of the First Street sewer complex and the Second Street sewer. Waste treatment and sewer use are described as follows:

<u>First Street 42" Sewer</u>

The First Street 42" sewer presently discharges once-through cooling water from the vinyl chloride/trichloroethane plant, the solvents plant (carbon tetrachloride and tetrachloroethylene) and the propylene oxide plant. Some stormwater runoff from the area of the propylene oxide plant also discharges to this sewer. This sewer is presently being replaced to eliminate infiltration and surface runoff with completion expected by mid 1991.

First Street 48" Sewer

The 48" sewer receives once-through cooling water only, and is above grade, thus precluding contamination by infiltration. The cooling water originates with the vinyl chloride/trichloroethane plant.

First Street 54" Sluice Sewer

The First Street 54" sluice sewer discharges once-through cooling water from the propylene oxide and chlorine II plants as well as surface runoff from the areas around both of these plants. Some process water (THROX scrubber) is presently discharged to the sluice sewer.

Second Street Sewer

The Second Street sewer receives once-through cooling water and stormwater runoff from the polystyrene and propylene oxide derivatives plants. Non-sanitary discharge from Dow's analytical laboratory also discharges to this sewer.

Third Street Sewer

The Third Street sewer discharges once-through cooling water and stormwater runoff originating with the high density polyethylene and latex plants. Non-sanitary discharge from the research and development building also discharges to this sewer. Cooling water and runoff from the styrene/ethylbenzene plant can discharge to the Third Street Sewer under certain hydraulic conditions, however, it normally discharges to the Fourth Street Sewer.

The steam stripper at the styrene unit treats process wastewater from the styrene, latex and HDPE plants, and contaminated storm runoff prior to discharge to a cross link between the Third and Fourth Street sewers. Before discharges reach the Fourth Street sewer, they are treated in the BIOX plant prior to discharge.

Fourth Street Sewer

The Fourth Street sewer discharges a mix of process, once-through cooling and stormwater to the river. Once-through cooling water comes from the low density polyethylene plant, chloralkali I plant, the styrene/ethylbenzene plant and the epoxy resins plant. Surface runoff from all these plants also discharges to the Fourth Street Sewer. Process water discharges to the Fourth Street Sewer come from the BIOX plant, the tank car washing facility, block 90 pond, and filter backwash and pH-treated effluent from the boiler feedwater treatment system at the power plant.

Fifth Street Sewer

The Fifth Street Sewer discharges once-through cooling water and stormwater runoff from the power plant area.

Block 90 Pond

Block 90 pond receives wastewater from the solvents and vinyl chloride plants, may receive process water from the First Street chlor-alkali plant (normally recycled), water from the recovery wells along the waterfront, and the tank car wash discharge. The solvents plant wastewater is made up of stripper bottoms and the vinyl chloride/trichloroethane wastewater originates with incinerator scrubber discharge, contaminated runoff and pH-adjusted process water. Wastewaters from the Block 90 pond are discharged to the Fourth Street sewer.

Effluent Quality

Loading data for regularly-monitored parameters at Dow Chemical are shown in Table 8.18. OMOE's industrial discharge reports provide a total loading value which represents the combined loadings from all seven outfalls. These data include the annual net averages and number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1989. Gross 1989 loadings for each outfall are shown in Table 8.19. Because these data are gross, they are not directly comparable to those in Table 8.18.

Dow Chemical is subject to Provincial effluent limits only, because Federal Regulations and Guidelines were never promulgated for the organic chemical industry. OMOE has developed site specific limits for each organic chemical plant. Dow Chemical is required to meet the following objectives on a monthly basis since 1985: total phenols - 20 μg/L; suspended solids - 15 mg/L; total organic carbon (TOC) - monitoring required.

Table 8.18 shows that Dow Chemical has been in compliance with its guidelines for phenols, suspended solids and total organic carbon from 1984 to 1989. Available data shows a steady decrease in TOC since 1986. Total phenols loadings in 1987 through 1989 were up to a third less than during earlier years.

It must be noted that these guidelines are based on total flow for the facility and not flow from individual outfalls. The relative contributions from the various outfalls during 1989 are shown in Table 8.19. However, because these data are gross, they include contributions from upstream sources (via the intake pipe). As expected, in all cases the gross loadings exceeded the net loadings.

One fish bioassay conducted in 1988 indicated that effluent from the 42" Sewer was non-acutely lethal to trout (OMOE 1989b).

A comparison of the annual self-monitoring data with data collected from the 1986 UGLCCS point source investigation, reveal a decrease in total phenols emanating from Dow sewers from 1.78 kg/d (1986) to 1.3 kg/d in 1989; and 7,045 kg/d suspended solids (1986/1987) to 2,620 kg/d in 1989.

As part of the UGLCCS 1986 point source survey and the OMOE MISA Pilot Site Investigations conducted in 1986 and 1987, the Dow First Street 42" and 54" sewers were determined as significant sources of hexachlorobenzene (HCB) to the St. Clair River. Although effluent quality cannot be directly compared to ambient water quality standards or guidelines, effluent concentrations exceeded the Provincial Water Quality Objectives of 0.0065 μg/L and the Michigan Rule 57 level of 0.0018 μg/L. Process streams containing hexachlorobenzene were diverted to a spill containment pond which now discharges to the Dow Fourth Street Sewer, subsequent to the UGLCCS investigation. The effect of this change appears to have reduced loadings of hexachlorobenzene, based on the more recent MISA data, from 0.03 kg/d in May of 1986 to 0.012 kg/d in the period from May 1986 to March 1987.

The loading of total volatiles measured during the UGLCCS investigation was 254 kg/d with benzene, chloroethane and toluene accounting for 72 percent of the total. Dow Chemical accounted for 20 percent of this total volatile loading.

Follow-up MISA investigations determined that loadings of total volatile organic compounds and chlorinated aromatic compounds to the St. Clair River from Dow Chemical Inc., were significantly reduced from November 1985 to the end of March 1987. Dow facility loadings were reduced in the order of 90 percent and 76 percent for these two groups of compounds, respectively.

Table 8.18 Annual average <u>net</u> loadings in kg/day and exceedences (# of months) of parameters under control at Dow Chemical Canada Inc., 1984 through 1989 (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	762.67	692.29	728.94	762.71	746.00	742.00
Total Phenols (kg/day)	1.30 (0)	0.98 (0)	0.95 (0)	1.82 (0)	2.80 (0)	3.20
Total Suspended Solids (kg/day)	2413.00(0)	2096.00(0)	3799.17(0)	1540.66(0)	2120.00(0)	2720.00
Total Organic Carbon (TOC) (kg/day)	231.00(0)	297.00	481.67	718.38	na	na

na = Data not available.

1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

Table 8.19 1989 <u>Gross</u> annual averages for each outfall at Dow Chemical Canada Inc. (OMOE 1990c). (These annual averages may include samples taken from the MISA monitoring program.)

Parameter	0200 1st St. 42" Sewer	0300 1st St. 48" Sewer	0500 1st St. 54" sluice	0600 2nd St. Sewer	0700 3rd St. Sewer	0900 4th St. Sewer	1000 5th St. Sewer
Flow m^3/day	50,083	61,400	30,583	64,000	87,000	457,700	11,900
Total Phenols (kg/day)	NA	NA	NA	NA	0.29	2.29	NA
Total Suspended Solids (kg/day)	450.1	440.0	284.0	565.0	412.0	3873.0	439.0
Total Organic Carbon (TOC) (kg/day)	99.360	119.0	64.1	141.0	174.0	993.0	23.0

NA = effluent not analyzed for this parameter.

Long term effluent sampling undertaken as part of the study, indicated that both the Cole Drain and the Dow 42" sewer are significant sources of eight parameters of concern selected for detailed assessment, particularly hexachlorobenzene, hexachlorobutadiene, hexachloroethane, and octachlorostyrene.

AMOCO Canada Petroleum Company Ltd., Sarnia

AMOCO operates a large natural gas liquids plant in Sarnia, with a capacity of 140,000 barrels per day. Natural gas liquids, shipped by pipeline from western Canada are fractionated into propane, butanes, pentanes and condensates. Normal butane is also converted to iso-butane. Both feed streams and product streams are stored in underground salt caverns.

Hydrocarbon streams at this facility operate in a closed loop and do not contact water so that no process wastewater is generated. Municipal drinking water is used for boilers and recirculating cooling system makeup. Cooling tower blowdown, boiler blowdown and all surface runoff from the site discharge to a holding pond and then pass through an oil separator before discharge to the Cole Drain. This discharge is intermittent, since the pond contents are only discharged when the depth of water in the pond reaches a preset level. Zinc/chromium-based inhibitors are not used in the recirculating cooling water system.

The average daily flow from this facility is 0.033 X 10^3 m^3/day (8.58 X 10^3 U.S. gal/d). No effluent limitations have been established, however the discharge would be subject to the Ministry of the Environment's general effluent criteria, such as the limits for discharges to municipal storm sewers (conventional, metals and total phenols). This facility is not required to report effluent control parameters for OMOE's annual report on industrial direct discharges. AMOCO was not surveyed during the 1986 UGLCC study, hence effluent discharge data is not available. Amoco was monitored under the MISA monitoring program and is currently monitored for flow, pH, conductivity and dissolved oxygen.

DuPont Canada Inc., Corunna

The St. Clair River site of DuPont Canada Inc., located at Corunna began operations in 1959. There have been several expansions of the plant since that time.

A complete range of low to high density linear polyethylene resins are manufactured using a low pressure cyclohexane solution process with ethylene and butene/octene. These resins find use in both flexible and rigid applications including piping, tile, containers and milk film bags.

Intake water for process and cooling is pumped from the St. Clair River at an average rate of about 46,000 m^3/day (11.96 X 10^6 U.S. gal/d). Process effluents, spent cooling water and storm water are passed through two ponds in series. A pellet skimming pond removes any polyethylene beads and a final skimming pond allows recovery of residual beads of plastic and other hydrocarbons prior to discharge through a single outfall to the river.

Effluent Quality

DuPont Corunna is subject to Provincial effluent guidelines only, since Federal Regulations and Guidelines were never promulgated for this sector. DuPont is subject to a 20 μg/L guideline for total phenols which originate with leaks in heat exchangers utilizing phenolic heat transfer fluids. Ketones are also monitored, however an effluent limit has not been set. Historically they have not been detected in the effluent and are analyzed only as a potential contaminant.

Loading data for regularly-monitored parameters at DuPont, Corunna are shown in Table 8.20. These data include the annual averages with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1989.

Table 8.20 Annual average net loadings in kg/day and exceedences (# of months) of parameters under control at DuPont Canada Inc., Corunna, 1984 through 1989 (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	49.11	48.17	46.08	44.72	44.60	na
Total Phenols (kg/day)	0.09 (0) 0.21 (Gross)*	0.11 (0)	0.39 (2)	0.25 (0)	0.72 (1)	0.25 (0)

na= Data not available.
* Data from OMOE files

1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

The effluent was in compliance with the phenols limit on an annual average basis for 1984 to 1989 (Table 8.20). During this time the level of total phenols discharged has been decreasing and there has been only one monthly exceedence in 1985 and two in 1987.

Esso Chemical Canada, Sarnia

Operations at Esso Chemical began in 1957 as part of the Imperial Oil Ltd. complex located along the St. Clair River in Sarnia's Chemical Valley. Esso Chemical presently operates manufacturing units which are located both within the Esso Petroleum refinery as well as on a separate site east of the refinery proper. The separate site is serviced by its own wastewater treatment facility which is outlined in this section.

Products manufactured at the Esso Chemical site include polyvinyl chloride (PVC), high density and linear low density polyethylene (LLDPE), naptha, lube oil additives, C_5-C_{15} olefins and fuel additives. Aromatics are also produced from feedstock supplied by the refinery, while ethylene and propylene are produced from natural gas.

PVC formulations are used in the manufacture of clothing, automobile trim, piping, wire insulation, window frames, swimming pool liners and house siding. Polyethylene is used for consumer packaging, cable insulation, piping and tiles.

Intake water at a rate of about 33,700 m^3/d (8.76 X 10^6 U.S. gal/d) is obtained from the Esso Petroleum refinery, which has two pumphouses on the St. Clair River.

The Esso Chemical Plant has two separate sewer systems, one for oily water and one for clean water. The clean water sewer receives PVC plant process water, polyethylene contact water, cooling tower blowdown and paved area stormwater.

Contaminated and potentially contaminated water from pump seals, the aromatics unit, flare seal drums and loading areas as well as stormwater, are collected and discharged to two parallel oil separators. The water discharge from the separators flows to the oily water impounding basin where further oil removal takes place via skimming. The oily water impounding basin discharge is pumped to the dual media filters (in parallel) which contain beds of sand and anthracite for additional removal of hydrocarbons. The dual media filter discharge passes through a single carbon contactor (a second contactor is on standby) and enters the clean water impounding basin.

The clean water impounding basin discharges to the St. Clair River. This is the only discharge from Esso Chemical.

Effluent Quality

Esso Chemical is only subject to Provincial effluent limits. OMOE has developed site-specific limits for each organic chemical plant. Esso Chemicals is required to meet the following objectives on a monthly basis since 1985:

Suspended Solids	15 mg/L
Total Phenols	20 μg/L
Oil and Grease	15 mg/L
Ammonia-Nitrogen	10 mg/L

Loading data for these regularly-monitored parameters at Esso Chemical Canada are shown in Table 8.21. These data include the annual averages with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1989.

Table 8.21 Annual average net loadings in kg/day and exceedences (# of months) of parameters under control at Esso Chemical Canada, Sarnia, 1984 through 1988[1] (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	30.41	33.66	28.49	29.70	21.50
Total NH^3-N (kg/day)	11.50 (0)	3.93 (0)	4.70 (0)	6.98 (0)	9.90
Total Phenols (kg/day)	0.032 (0)	0.031 (0)	0.06 (0)	0.23 (0)	0.30
Total Suspended Solids (kg/day)	154.00 (0)	26.67 (0)	120.74 (0)	298.00 (1)	188.00
Oil and Grease (kg/day)	7.37 (0)	8.71 (0)	9.74 (0)	26.90 (0)	16.00
Total Organic Carbon (TOC) (kg/day)	162.00	114.49	86.23	na	na

na Data not available

1 1989 data are gross, and hence not comparable to earlier data
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

Table 8.21 shows that the final effluent was in compliance from 1984 to 1989 for phenols, ammonia-nitrogen, and oil and grease. There was only one monthly suspended solids exceedence which occurred in 1985. Over the period of record, total phenols and oil and grease loadings have decreased. Total organic carbon was twice as high in 1988 as it was in 1986. The other parameters show no clear trend.

The 1986 UGLCCS (1988) point source survey indicated that Esso Chemical was a point source discharger to the St. Clair River of vinyl chloride, total organic carbon, zinc and arsenic (OMOE 1989c).

Ethyl Canada Inc., Corunna

The Ethyl Canada plant at Corunna is located south of the Shell refinery, along the St. Clair River (Figure 8.1). Production of tetraethyl lead (TEL) from lead-sodium alloy and ethyl chloride began at the site in 1956. Since that time, the site has expanded production to include tetramethyl lead, ethyl chloride and diesel ignition improvers. Also on site is a blending and packaging facility for aluminum alkyls, manganese antiknock compound, phenolic antioxidants, and lubricating additives.

Intake water to the plant, at an average rate of 33,300 m^3/d (8.66 X 10^6 U.S. gal/d), is supplied by Shell Canada, which obtains its water from the St. Clair River.

The tetraethyl (TEL) and tetramethyl (TML) plant is a secondary lead smelter where inorganic lead is combined with ethyl or methyl chloride to produce alkyl lead. Lead furnace scrubber water and other contaminated wastewater discharge to a sludge pit for settling of lead solids. Effluent from the sludge pit is pH adjusted and treated with iron sulphate, sodium borohydride and polyelectrolyte to reduce alkyl lead to lead. The resulting lead particles are removed in a lamella settler. Recovered lead is subsequently recycled. The resulting effluent is then sent to an aeration tank prior to being discharged to the plant sewer system.

Heavy ends from the production of ethyl chloride are treated in a hydrolyser followed by an oil water separator (the oil is used as supplemental fuel for the furnace). The resulting acid water discharges to the fume scrubber where the gases and fumes from the heavy ends are removed. The resulting scrubber water discharges to a neutralization pit to raise the pH and then discharges to the plant sewer system. A water stream containing hydrocarbons from the production of diesel ignition improver (2-ethylhexyl nitrate) also discharges to the neutralization pit.

The blending and packaging facility does not generate process effluent.

Treated process effluents combine with once-through cooling water and stormwater, and are then discharged through a single outfall to the St. Clair River.

<u>Effluent Quality</u>

Ethyl Corunna is subject only to Provincial, plant-specific guidelines. Diesel Ignition Improver is specified under CofA # 4-026-85-878 and alkyl lead concentration limits are set under CofA # 4-021-86-006. Ethyl's guidelines or requirements are as follows:

Diesel Ignition Improver	248 μg/L (8.45 kg/d)
Total Lead	0.5 mg/L
1,2-Dichloroethane	600 μg/L
1,2-Dibromoethane	14 μg/L
1,1-Dichloroethylene	50 μg/L
Alkyl Lead	< 0.128 mg/L

Loading data for total lead from Ethyl Canada Inc., Corunna are shown in Table 8.22. These data include the annual averages (all years are gross data) with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1989.

Table 8.22 Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Ethyl Canada Inc., Corunna, 1984 through 1989 (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	35.37	34.18	33.27	19.34	26.40	33.90
Total Lead (kg/day)	8.71 (0)	10.60 (0)	7.15 (0)	8.73 (5)*	22.70 (11)	27.20 (all samples)

* Effluent concentration guideline for lead was out of compliance for 5 months. Loading guidelines (calculated in respect to flow) were in compliance.

1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

In 1984 the effluent limit for total lead was reduced from 1.0 mg/L to 0.5 mg/L in order to conform with the OMOE interim objective. As a result, the effluent was not in compliance with the annual average limit for lead in 1984. In 1985, when compliance was interpreted on a monthly basis, the plant was out of compliance for eleven months (Table 8.22). Table 8.22 also shows the frequency of non-compliance was reduced to 5 months in 1986 (OMOE 1990b) and finally full compliance was achieved from 1987 through 1989. The loadings of lead from this facility decreased by to a third from 1984-85 to 1986.

An Environment Canada survey of the plant's effluent in 1984 found high levels of ethylene dichloride, ethylene dibromide and ethyl chloride. Ethylene dichloride production was subsequently discontinued in 1986 but it is now a purchased raw material for blending with TEL.

During the 1986 UGLCCS (1988) point source investigation, the total loading of lead from all sources to the St. Clair River was 29 kg/d, 66 percent of which was attributed to Ethyl Canada. A comparison of lead loadings between the 1986 UGLCCS data (19.1 kg/d) and the 1989 self-monitoring data (8.71 kg/d), indicates that discharges of this parameter have decreased by more than half. However, the UGLCCS Survey was based on only a 3 to 6 day period whereas the data in Table 8.22 represent daily sampling over a one year period.

The 1986 UGLCCS (1988) data also indicated that the plant was a point source discharger to the St. Clair River of PAHs, chlorides, ethyl chloride, ethylene dichloride and ethylene dibromide. Further, 17 percent of the load of total volatiles (254 kg/d) to the St. Clair River was attributed from the Ethyl Canada facility.

As of this writing, Ethyl Canada is proposing to upgrade the environmental controls to 'Best Available Technology' at its Corunna facility. Planned water treatment improvements is estimated at $ 8.1 million (U.S.) resulting in reductions of total lead discharges in the order of 50 percent below current loadings. Air emission controls will also be instituted. It is anticipated that the improvements in water treatment will be completed by the third quarter of 1992, pending appropriate approvals for construction.

Novacor Chemicals (Canada) Ltd., Mooretown

Novacor Chemicals operates the former Union Carbide Canada Ltd. plant located in Mooretown, east of Corunna. The plant was built between 1974 and 1977 and went into full production in 1978. An environmental impact assessment was conducted prior to construction in order that environmental considerations would be included as part of the facility design.

High density and low density polyethylenes are produced continuously at the site using low pressure and high pressure gas phase polymerization processes. Minor quantities of polymeric oils and waxes are also produced.

Polyethylene finds wide application in consumer packaging, piping and wire insulation.

Intake water at a rate of about 3,000 m^3/d (780,000 U.S. gal/d) is provided by the Sarnia water supply system. The use of a cooling tower reduces the overall demand for fresh water. The main use of the water is for non-contact cooling in heat exchangers and contact cooling for polymer during extrusion.

Contact cooling water, building drains and dyked area stormwater are collected and discharged to a process pond to allow for the settling of solids. Building drain and dyked area water is quality-tested before being discharged to the pond. Cooling tower blowdown and boiler blowdown are directed to the process pond prior to discharge to the river. Sanitary wastewater is treated on-site in a package biological plant and is then chlorinated prior to discharge to the process pond. The process pond effluent discharges through an extended submerged outfall. In 1988, a filter was installed on the effluent discharge line in order to reduce the levels of suspended solids. In 1990, the process pond was lined with an impervious substrate, covered with a polyethylene webbing and crushed stone, in order to control silting (OMOE 1990b).

Stormwater is collected in two parallel retention ponds where solids are allowed to settle out. Over-under weirs also capture any floating polymer pellets which make their way into the system. The stormwater retention ponds normally discharge to the process pond, however, under high flow conditions such as during spring thaw or heavy rains, the pond will overflow to a municipal ditch which is a tributary to Baby Creek. Baby Creek discharges to the St. Clair River.

Effluent Quality

Loading data for regularly-monitored parameters at Novacor Chemicals Ltd. are shown in Table 8.23. These data include the annual averages (all years are gross data) with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1988.

Novacor is subject only to Provincial effluent guidelines. Compliance has been interpreted in terms of: 15 mg/L suspended solids; and 1.0 mg/L total phosphorus. Effluent was in compliance with these objectives on an annual average basis for 1984. Since 1985, compliance has been on a monthly average basis. Table 8.23 shows that Novacor has had repeated exceedences of the suspended solids guideline. As described earlier, Novacor has recently taken measures to further reduce its discharge of suspended solids. This is reflected in the 1989 loadings which were lower than in any previous year. There are no clear trends over time for total organic carbon or TKN, however, loadings of total phosphorus were approximately half in 1987-89 compared to previous years (Table 8.23).

Table 8.23 Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Novacor Chemicals Ltd., Mooretown, 1984 through 1989 (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	1.52	1.82	1.74	2.22	2.18	2.36
Total Kjeldahl Nitrogen (kg/day)	1.59	2.97·	4.10	2.34	na	na
Total Phosphorus (kg/day)	0.50 (0)	0.61 (0)	0.68 (0)	1.55 (1)	1.50 (2)	3.20
Total Suspended Solids (kg/day)	21.67 (2)	81.20 (9)	47.12 (10)	37.44 (4)	58.80 (9)	31.10
Total Organic Carbon (TOC) (kg/day)	11.60	12.30	19.37	12.38	na	na

na = Data not available.

1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

Polysar Rubber Corporation/Novacor Chemicals (Canada) Ltd, Sarnia

The original Polysar Ltd. manufacturing complex is located along the St. Clair River bordered by Esso Chemical Canada/Esso Petroleum Canada to the north and Dow Chemical Canada to the south (Figure 8.1). The company was sold and reorganized in 1990 and now the faciliy is comprised of two organizations, Novacor Chemicals (Canada) Ltd., which owns the two Styrene plants, and Polysar Rubber Corporation, which controls all other facilities and landfills. Novacor's Styrene I plant has been shut down and is currently planned for demolition. Although the original Polysar facility now represents two organizations, some of their discharges are still combined and it is therefore currently impossible to treat them individually.

Polysar/Novacor was originally formed as Polymer Corporation Limited in 1943 to address the shortage of natural rubber which occurred during wartime. Today, Polysar produces nitrile-butadiene, styrene-butadiene, polybutadiene, and butyl and halobutyl rubbers. Polysar also extracts isobutylene and butadiene from C_4 fractions. Novacor (Sarnia) produces styrene and ethylbenzene.

Intake water, averaging about 550,000 m^3/d (143 X 10^6 U.S. gal/d) is obtained from the St. Clair River by Polysar. Approximately 70 percent of the water is used in-house for process, once-through cooling, boiler feed water and cooling tower makeup requirements. The remaining 30 percent is distributed to neighbouring companies.

Four process wastewater streams from the Polysar Butyl and Polybutadiene facilities and the two Novacor Styrene facilities are treated at the source in the production units. The treated stream from the Butyl facility is discharged directly into the 66" sewer. Part of the treated stream from the Polybutadiene facility is discharged into the 72" sewer. Both the 66" and 72" sewers discharge into the St. Clair River. The Novacor Styrene wastewater streams are further treated in the Polysar Biological Oxidation Wastewater Treatment Plant (BIOX).

All other process water streams are pretreated for solids removal, oil removal, pH, etc., depending on the waste stream before discharging to the on-site Polysar BIOX plant, which has been in operation since 1983.

The high variability of process effluents results in their discharge to a pre-aeration equalization tank before entering the BIOX plant. The equalized wastewater is combined with outside wastewater from neighbouring plants not owned by Polysar Rubber or Novacor Chemicals (Canada) Ltd. The CofA for the BIOX plant allows Polysar Rubber to accept outside wastes approved by the OMOE.

At the BIOX plant, a combined wastestream passes through the unit which consists of four aeration tanks and four secondary clarifiers. The tanks have the flexibility of being used in series or parallel, as required, in order to achieve maximum removal efficiency. The BIOX plant effluent is discharged to the Cole Drain near the bank of the St. Clair River. The Cole Drain, which originates upstream of the Polysar/Novacor complex, flows through the Polysar property and discharges into the St. Clair River via a submerged, extended outfall. Polysar also discharges once-through cooling water and some storm water into the Cole Drain.

Polysar has three direct, shore-based discharges to the St. Clair River described as follows:

54" Sewer

The 54" sewer discharges once-through cooling water, stormwater and boiler blowdown (from the steam plant) to the St. Clair River. The average flow of this sewer is approximately 175 to 200 X 10^3 m^3/d (45,500 to 52,000 U.S. gal/d).

66" Sewer

The 66" sewer discharges once-through cooling water, stormwater and process wastewater to the St. Clair River.

Rubber-containing streams from the Butyl plant are treated by an API-type separator for oil and hydrocarbon recovery followed by dissolved air floatation for rubber crumb recovery. The treated stream combines with cooling tower blowdown and discharges to the Polysar BIOX Plant.

Contaminated wastewater from the Novacor Styrene plant has oil and hydrocarbons skimmed off prior to discharging to a stripping tower for TOC removal, followed by ozonation to destroy phenolics. The pH can be adjusted and the effluent clarified if necessary. The treated wastewater discharges to the 66" sewer.

Oil- and hydrocarbon-contaminated streams from the Polybutadiene plant pass through a steam stripping tower if contaminated with benzene. The effluent is then transferred to the BIOX plant.

72" Sewer

The 72" sewer receives once-through cooling water, stormwater and process wastewater. The Polybutadiene plant finishing wastewater passes through a separator to remove Polymer solids prior to discharge.

Other Discharges

In addition to the three direct discharges, Polysar has one more once-through cooling water outfall discharging to the St. Clair River plus two once-through cooling water outfalls, one treated water outfall from the BIOX Plant, and five stormwater outfalls discharging to the Cole Drain.

Effluent Quality

Polysar/Novacor is subject to only Provincial effluent guidelines. The Ministry's general concentration guidelines are as follows:

Ammonia-nitrogen	10 mg/L
Total Phenols	0.020 mg/L (20 μg/L)
pH	5.5 - 9.5
Suspended Solids	15 mg/L
Oil and Grease	15 mg/L

These requirements are tied to the total flow from the facility as opposed to individual sewers or process effluents. Loading data for regularly monitored parameters at Polysar/Novacor, Sarnia, are shown in Table 8.24. OMOE's Industrial Discharge Reports combine the four outfalls discharging treated wastewater into one table in order to determine the total loadings for Polysar/Novacor, Sarnia. These data include the annual net averages and number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1989. Net 1989 loadings for each individual outfall are shown in Table 8.25.

Table 8.24 Annual average net loadings in kg/day and exceedences (# of months) of parameters under control at Polysar Rubber Corporation and Novacor Chemicals (Canada) Ltd, Sarnia, (both formerly Polysar Ltd.), 1984 through 1989 (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	364.70	328.68	291.5	258.63	252	255
Total NH_3-N (kg/day)	12.21 (0)	29.00 (0)	125.69 (0)	172.60 (0)	205.00 (0)	283.00
Total Phenols (kg/day)	0.40 (0)	0.39 (0)	0.45 (0)	0.39 (0)	0.87 (0)	0.92
Total Suspended Solids (kg/day)	0* (0)	0* (0)	1780 (0)	1216 (0)	1490 (0)	1730
Oil and Grease (kg/day)	3.68 (0)	0.62 (0)	43.25 (0)	47.90 (0)	51.80 (0)	58.70
Total Organic Carbon (TOC) (kg/day)	773.00	877.00	1317.38	900.00	na	na

0* Indicates intake exceeded discharge loading.
na = Data not available.
1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

Table 8.24 includes total flow from the 54", 66", 72" and BIOX sewers. Table 8.24 shows that Polysar/Novacor has been in compliance with its guidelines for ammonia-nitrogen, phenols, suspended solids, and oil and grease from 1984 through 1989. The data in this table also indicate that loadings of ammonia-nitrogen, total phenols, oil and grease, and total organic carbon have decreased steadily over the period of record. Net suspended solids loadings decreased to zero after 1987. Although the net data for the BIOX sewer shown in Table 8.25 indicated an average annual loading of 185 kg/d, the reported net loading for all sewers is zero (Table 8.24). This indicates that, although the plant contributed sediment to the river during some months, in total it removed more sediment than it contributed over the one year reporting period.

Table 8.25 The 1989 net annual average loadings for each outfall at Polysar Rubber Corporation and Novacor Chemicals (Canada) Ltd, Sarnia (formerly Polysar Ltd.) (OMOE 1990c).

Parameter	0200 72" sewer	0400 66" sewer	0500 54" sewer	0600 BIOX discharge (Polysar/Novacor/BASF/AKZO)
Flow X 10^3 m^3/day	38.15	193.93	114.00	13.37
Total NH_3-N (kg/day)	0.060	0	0	12.07
Total Phenols (kg/day)	0.040	0.075	0.095	0.190
Total Suspended Solids (kg/day)	0	5	37	185
Oil and Grease (kg/day)	0	0	0	3.35
Total Organic Carbon (TOC) (kg/day)	24	150	94	488

A point source effluent survey conducted by UGLCCS (1988) in 1986 indicated that Polysar/Novacor was a point source discharger to the St. Clair River of phenols, cyanide, oil and grease, nickel, cobalt, phosphorus, ammonia-nitrogen, total organic carbon, polycyclic aromatic hydrocarbons, oil and grease and two volatile organics - benzene and chloromethane (UGLCCS 1988). The UGLCCS investigations indicated that Polysar/Novacor Sarnia facility exceeded the Ontario Industrial Discharge Objective of 20 μg/L for total phenols and 10 mg/L for ammonia-nitrogen. An estimated total point source loading of 1,670 kg/d of ammonia to the St. Clair River included contributions from the Polysar/Novacor facility in Sarnia of 350 kg/d from the BIOX effluent. Of the total volatiles, on the order of 254 kg/d for all sources, measured during the UGLCCS investigation, the Polysar/Novacor Sarnia facility was responsible for approximately 51 percent.

Results from the 1989 OMOE Industrial Dischargers Report (Table 8.24) indicate that significant improvements have been noted in current loadings of ammonia-nitrogen and total phenols, as compared to loadings measured during the 1986 UGLCCS investigation. Reductions on the order of 96.5 percent and 63 percent have been noted for these two parameters, respectively.

As part of the 1986/87 Ontario Ministry of the Environment MISA Pilot Site Investigation, it was determined that loads of all contaminants, with the exception of octachlorostyrene, from the Polysar 72" sewer were sufficiently low to ensure the protection of aquatic life.

In April, 1988, Polysar/Novacor announced a five year, $20 million plan to modernize and upgrade its facilities which impact on the environment (OMOE 1989c).

Cole Drain

The Cole Drain is an open ditch system servicing an area south of Sarnia's residential and business core. The drainage system is bounded approximately by the CNR railway track south of Confederation Street on the north, Modeland Road on the east, Churchill Road on the south and the St. Clair River on the west. It receives stormwater runoff from undeveloped and developed land, waste disposal and product storage areas, treated and untreated runoff and industrial process effluent and cooling water.

The first major upstream influence is the Scott Road Ditch which serves an industrial and municipal waste disposal area. Waste disposal sites along Scott Road are owned and operated by Polysar Rubber Corp., Dow Chemical (not currently active), Fiberglas (not currently active), Esso Petroleum and Esso Chemical, as well as the City of Sarnia (sewage sludge disposal lagoons). The Scott Road Ditch runs along the western edge of the industrial waste disposal area and receives treated leachate and storm runoff before joining the Cole Drain.

Partek Insulation Limited (formerly Holmes Insulation) is located on Scott Road and discharges cooling water and surface runoff from the plant and raw material storage yard to the Scott Road Ditch opposite the Esso disposal site.

The Cole Drain, upstream from its intersection with the Scott Road Ditch, receives surface runoff from the areas of Plank and Indian Roads and the MacGregor Side Road. The CN yard runoff passes through an oil-water separator and also discharges to this part of the Cole Drain. AMOCO Canada Petroleum Company Ltd. discharges cooling tower blowdown and storm runoff to the Cole Drain upstream of CN.

Downstream of the Cole Drain-Scott Road Ditch intersection, as far as Vidal Street, the Cole Drain receives inputs from Esso Chemical (stormwater), Cabot Canada Inc. (cooling tower and boiler blowdown, laboratory wastes, equipment wash water, surface runoff and treated process water), Fiberglas Canada Inc. (process and cooling waters) and Polysar Rubber Corporation (stormwater). BASF and AKZO (cooling water and surface runoff) also discharge to the Cole Drain.

The final section of the Cole Drain is lined with concrete and flows through Polysar Rubber Corporation property. It receives mainly cooling water and stormwater, as well as research laboratory wastewater. The Polysar Rubber Corporation BIOX plant discharges to the Drain immediately upstream of the Drain's submerged outfall to the St. Clair River.

The Cole Drain was sampled in 1986 for the UGLCC study. Samples were taken over a 3 day period from May 13 to 16, 1986 at two locations, one being upstream of the Scott Road Ditch intersection and Esso Petroleum tank farm, the other upstream of the Polysar Rubber Corp. BIOX discharge. In terms of loadings, the Cole Drain outfall (before the Polysar BIOX outfall) to the St. Clair River was found to be among the major sources of: total phenols, PAHs, total cyanide, oil and grease, selected heavy metals (zinc, mercury, copper, nickel, iron), TOC and total suspended solids (UGLCCS 1988). The concentrations of these pollutants were consistently low, due to a heavy rainfall on the third day of sampling, which indicated that the relatively high flow in the Drain determined the degree of pollutant loading.

Results from the 1986/87 MISA Pilot Site Investigation identified the Cole Drain as a significant source of parameters of concern, particularly hexachlorobenzene, hexachlorobutadiene, hexachloroethane and octachlorostyrene. It is important to note that the Cole Drain was not identified in the UGLCCS investigation as a principle contributor of these parameters.

The Cole Drain and its major feeders including the Scott Road Drain and the Polysar Perimeter Drain were sampled for PAHs, chlorinated organics, chlorophenols and volatile organics during May 1986. This investigation was conducted by Conestoga Rovers and Associates (1989) as a follow up to specific recommendations of the federal/provincial St. Clair River Pollution Investigation Report (Environment Canada/OMOE 1986). Table 8.26 summarizes loadings of total volatile organics (lower molecular weight volatile organics) and total chlorinated organics (chlorinated aromatic organics) representing the Cole Drain, Scott Road Drain and Polysar Perimeter Drain upstream of their confluence.

Table 8.26 Loadings of total volatile organics and total chlorinated organics (kg/d) from the Cole Drain, Scott Road Drain and Polysar Perimeter Drain calculated during three sampling rounds in May 1986 (Conestoga Rovers and Associates 1989).

Parameters	Sampling Round	Cole Drain[1]	Polysar Perimeter Drain	Scott Road Drain	Total
Volatile Organics	Dry Weather #1	0.006	0.061*	0.027**	0.094
	Dry Weather #2	0	0.060*	0.044**	0.104
	Rainfall Event	0	0.044*	1.023**	1.067
Chlorinated Organics	Dry Weather #1	0.00004	0.00009	0	0.00013
	Dry Weather #2	0	0.00050	0.0005	0.00100
	Rainfall Event	0	0.00002	0.0033	0.00332

[1] The Cole Drain sample was taken upstream of its confluence with the Scott Road Drain and the Polysar Perimeter Drain, hence, total loadings to the St. Clair River is the total of all three loadings.

* primarily 1,1,2-trichloroethane
** primarily tetrachloroethylene

The major conclusions derived from this survey are:

1) the calculated loadings of total volatiles and total chlorinated organics (Table 8.26) for these drains are very low relative to other point sources;

2) the loading of volatile organics is much higher than for chlorinated organics. PAHs and chlorophenols were generally not detectable;

3) total loadings of volatile organics to the St. Clair River from the Cole Drain (0.094 to 1.067 kg/d) are comparable in magnitude to that determined by the 1986/87 MISA Pilot Site Investigation for volatiles but are an order of magnitude less than the 1985 data reported by Environment Canada/OMOE (1986). For example, the sum of 1,1-dichloroethane, 1,2-dichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 2,4,5-trichlorotoluene and tetrachloroethylene (Table 8.26) is 0.2798 kg/d for the 1986/87 data and 10.71 kg/d for the 1985 data;

4) in general, most of the loadings of volatiles and chlorinated organics are contributed at base flow (seepage from landfills, industrial effluents and/or shallow groundwater). Storm runoff did not contribute contaminants to the drains with the exception of the Scott Road Drain. The large additional loadings of volatiles to this drain during the wet weather sampling was considered almost exclusively tetrachloroethylene (90.5 μg/L);

5) the source of tetrachloroethylene to the Scott Road Drain is not clear, however, the authors suggested sediments or an unidentified tile drain;

6) other volatiles contributing to the Scott Road Drain were dichloromethane and chloroform. Sources were not identified but inputs occurred in the section of drain fronting the Fiberglas and Dow disposal sites as well as the Polysar Flyash Pond; and

7) for the Polysar Perimeter Drain, primary volatiles included 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane and 1,2-dichloroethane. The authors concluded that seepage from the embankment of the Polysar Flyash Pond along with seepage directly to the ditch are the primary sources of priority pollutants present in the Perimeter Drain during dry weather flow conditions.

8.2.4.1.4 Inorganic Chemicals Sector

Descriptions of facilities representing the inorganic chemicals sector are based on their 1991 status.

Cabot Canada Ltd., Sarnia

The Cabot Canada facility is located in Sarnia (Figure 8.1). It manufactures carbon black using the oil furnace process and has an annual capacity of 90,000,000 kg. Aromatic tars are heated in the presence of air in a refractory-lined furnace, where they are cracked at approximately 1600^{0} C into carbon and hydrogen. The carbon black is separated from the flue gas by filter bags and the hydrogen-bearing flue gas is burned in a boiler to produce steam.

Carbon black is used in the manufacture of automotive tires, inks, paint pigments and carbon paper.

Intake water is supplied from Polysar, Sarnia at a rate of 240 m^3/d (62,400 U.S. gal/d). Water is used in the process as a quench to control temperature after the cracking reaction. Water is also added to the pelletizing process.

All stormwater that accumulates on-site is collected and treated with alum to precipitate suspended solids in a settling lagoon. The lagoon also collects water from cooling tower and boiler blowdowns, air conditioning units, laboratory wastes and equipment wash water. A second lagoon on-site is used as a stand-by. Wastewater is then filtered through sand and flyash before being discharged to the Kenny St. Ditch and subsequently to the Cole Drain.

<u>Effluent Quality</u>

Final effluent was sampled daily (grab) for suspended solids, oil and grease and total phenols until 1991. Dry weather effluent discharge is approximately 0.55 X 10^3 m^3/d (143 X 10^3 U.S. gal/d). A 1973 CofA required Cabot to meet the following effluent requirements:

Oil and Grease	< 15 mg/L
Suspended Solids	< 15 mg/L

Other OMOE requirements:

Total Phenols	0.020 mg/L (20 μg/L)

Since August, 1985, Cabot's process effluent has been below the industrial discharge objective for total phenols. Cabot is in compliance for oil and grease and suspended solids requirements (OMOE 1990b).

Fiberglas Canada Inc., Sarnia

Fiberglas Canada was located on Kenny Street in Sarnia and began operating in 1948. It has since shut down and is currently being decommissioned. The plant produced various grades of glass fibre insulation for home building, commercial and industrial applications.

The insulation is composed of glass fibres bound together with a phenol-formaldehyde thermosetting resin. Boro-silicate glass, which is produced in an electric-arc furnace, is fed as a melt to a fibre forming machine. Phenol-formaldehyde binder is then sprayed onto the fibres as part of the forming process. Binder-coated fibres are formed into a continuous 'pack' on a conveyor. Some of the products are conveyed to a gas-fired curing oven to set the resin and then shaped and packaged to final product specifications. Roofing and acoustical products are imparted with a facing material on the insulation.

Intake water was supplied from Polysar Rubber Corporation. Water was used for cooling glass fibre insulation, to cool and solidify the molten glass stream when the unit is being shut down (cullet water), as make-up water for binder solution, and for washing down conveyors and equipment. Once-through cooling water was used for the furnace, compressors and emergency generators. Water which contacted the binder materials was recycled into the process as binder dilution water, with any excess hauled away as liquid industrial waste. The cullet water was screened for glass beads before being discharged to the Cole Drain. Recovered glass beads were recycled into the furnace.

Fiberglas Canada formerly operated a solid waste disposal site at Scott Road. Liquid effluent from this facility is pumped to Dow Chemical for treatment, after which it was returned to Fiberglas for storage. This liquid was then shipped for disposal as liquid industrial waste.

Effluent Quality

Loading data for formerly regularly monitored parameters at Fiberglas Canada Inc., are shown in Table 8.27. These data include the annual averages (all years are gross data) with the number of monthly exceedences in parenthesis for the monitored parameters, from 1985 through 1989. Even though the facility has since closed, the data are presented for comparison with other dischargers during the period for which ambient data are available (Chapter 6).

Table 8.27 Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at Fiberglas Canada Inc., Sarnia, 1985 through 1989 (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]	1985[5]
Flow (1000 m^3/day)	4.69	5.04	5.44	6.35	7.37
Total Phenols (kg/day)	0.015 (0)	0.035 (2)	0.030 (0)	0.030 (0)	na (2)

na = data not available.
1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b

Fiberglas Canada was subject only to OMOE guidelines for pH and total phenols: 5.5-9.5 and 20 $\mu g/L$ respectively. Table 8.27 shows that Fiberglas Canada was in exceedence for total phenols during two months in 1985 and for two months in 1988. The average annual total phenol loading decreased in 1989 to a level less than one-half of the previous years and Fiberglas was in compliance for this parameter during all months in 1989 (Table 8.27).

ICI Nitrogen Products, Courtright

ICI Nitrogen Products, formerly CIL Limited, is located on the south side of the Moore-Sombra Township Line, adjacent to the St. Clair River (Figure 8.1). The plant came on-stream in 1967 and has a present capacity in excess of 1,150,000 tonnes/year (1,267,300 tons/year). It is one of the largest fertilizer facilities in Canada and manufactures anhydrous ammonia, granular urea, urea solution, sulphur-coated urea, ammonium nitrate, nitric acid, nitrogen solutions and carbon dioxide. Prior to 1986, this plant also produced phosphoric acid and ammonium phosphate.

Ammonia is produced by the reaction of hydrogen gas with nitrogen gas over a catalyst at elevated temperatures and pressures. Natural gas is reformed at high temperatures to supply hydrogen, while nitrogen is supplied from the air. Carbon dioxide is formed as a by-product.

Urea is manufactured by the reaction of ammonia with carbon dioxide to form ammonium carbamate, which is then dehydrated to give a final urea product solution. Solid urea is formed by subjecting this urea solution to granulation. Some of the urea is then coated with liquid sulphur to be sold as sulphur coated urea.

Nitric acid is produced by reacting ammonia with air over a catalyst at high temperature to give nitrogen dioxide, which is then absorbed in water to produce nitric acid. Ammonium nitrate is manufactured by neutralizing ammonia with nitric acid in a reactor to form ammonium nitrate solution. This solution is then "prilled" to form solid grains or prills of ammonium nitrate.

Intake water is pumped from the St. Clair River at a rate of approximately 150,000 m^3/d (39 X 10^6 U.S. gal/d).

Process condensate from the ammonia plant is treated by a tray-tower type stripper (Braun Stripper) prior to discharge. The ammonium sulphate recovered was previously consumed by the phosphoric acid plant, prior to its shut-down in 1986. Ammonium sulphate is now recycled through a stripper at the ammonia plant. Floor washings and contaminated water from the ammonium nitrate prill plant are recovered and recycled. Process water from the urea plant is used to manufacture nitrogen solutions. Fresh water, treatment plant effluent and boiler and compressor blowdown discharge to the cooling water sewer. Sanitary sewage receives biological treatment prior to discharge. The surface ditch system collects all runoff from the site, including runoff from raw material and product offloading/loading areas. This system includes an automatically activated spill containment lagoon, and gate valves on certain sections so that the discharge of potentially contaminated runoff can be manually controlled.

Process wastewater, once-through cooling water, and surface runoff discharge to a network of open and closed sewers, and ditches which are combined to give a single final effluent discharge into the St. Clair River.

In 1986 the phosphoric acid plant was shut down. Remaining, however, is a large gypsum stack and a series of holding ponds. The holding pond to the immediate south of the gypsum stack stores contaminated water, that percolates from the stack prior to lime treatment. The remaining ponds contain lime treated water in various stages of lime settling and polishing ponds, where natural biodegradation has occurred for varying time frames.

Gypsum is a by-product of the extraction of phosphorus from phosphate ores, and due to low concentrations of naturally- occurring radium 226 in phosphate ores, the by-product is also slightly radioactive. The radium remains with the gypsum after phosphorus removal. The water in the lagoons, after settling to remove gypsum crystals, was recycled to the phosphoric acid plant with excess water overflowing intermittently to the plant sewers. Sulphuric acid from another ICI plant manufacturing explosives was used at one time to extract phosphorus from the ore. This acid was contaminated with 2,4-dinitrotoluene which is also present in the gypsum ponds. Fluoride from the ore is also present. ICI planned to drain the ponds over a three-year period as a first step in decommissioning the lagoons. However, the Control Order allowing the discharge of dinitrotoluene was revoked and the lagoon discharge was shut off in October 1987, due to public concerns for drinking water quality. As an interim measure to reduce the amount of contaminated water requiring treatment, ICI was issued a CofA to apply a 2 ft (0.6 m) clay cover to the 28 ha (69.2 acres) top of the stack. This project was completed in the summer of 1989. In 1990 a CofA was issued to ICI to further reduce infiltration of water to the gypsum stack by covering the sides with 3 ft (1 m) of clay and a further covering of top soil to establish vegetation. This project was completed in the summer of 1990.

Effluent Quality

Loading data for regularly monitored parameters at ICI Nitrogen Products, Courtright, are shown in Table 8.28. These data include the annual gross averages with the number of monthly exceedences in parenthesis for the monitored parameters, from 1984 through 1989.

Table 8.28 Annual average gross loadings in kg/day and exceedences (# of months) of parameters under control at ICI Nitrogen Products, Courtright, (formerly CIL Inc.), 1984 through 1989 (OMOE 1990b,c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]	1985[5]	1984[6]
Flow (1000 m^3/day)	355.86	305.61	303.92	270.70	348.00	288.00
Dinitrotoluene (kg/day)	na	na	3.53 (0)	9.30 (0)	na	na
Total Fluoride (kg/day)	35.40	30.70	68.98	32.50 (0)	39.10 (0)	35.70 (0)
Total NH_3-N (kg/day)	226.00 (0)	300.00 (0)	478.33 (0)	430.34 (0)	458.00 (0)	124.00 (0)
NO_2 + NO_3 -N (kg/day)	156.00	153.00	319.34 (0)	275.40	na	na
Total Phosphorus (kg/day)	3.91 (0)	16.40 (0)	29.16 (0)	14.40 (0)	24.90 (0)	14.90 (0)

na = Data not available.
1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b
5 1985 data from OMOE files 1990b
6 1984 data from OMOE files 1990b

As previously mentioned, the Control Order was revoked in 1987 (dinitrotoluene was not to be discharged), however, Table 8.28 shows that ICI was in full compliance with its guidelines for dinitrotoluene, fluoride, ammonia-nitrogen, nitrite + nitrate and total phosphorus based on annual averages for 1984 and has continued to be in compliance with monthly averages from 1985 through 1989. Average annual loadings of ammonia-nitrogen, total phosphorus and nitrate plus nitrite all decrease by about one-half in 1988-89 compared to earlier years.

The final effluent from this facility was sampled in 1986 as part of the UGLCCS study. The survey identified ICI as being a major source of iron, ammonia, nitrogen and suspended solids (UGLCCS 1988).

Linde, Mooretown; Linde, Sarnia; Liquid Carbonic, Moore/Sombra Town Line; Liquid Carbonic, Sarnia; Air Products, Sarnia; and Cardox, Courtright

Linde, Liquid Carbonic, Cardox and Air Products all produce air products such as nitrogen, oxygen, carbon dioxide and hydrogen. These facilities do not have significant discharges. Liquid Carbonic (Moore/Sombra) and Cardox (Courtright) are monitored under MISA. However, Cardox has been shutdown since November, 1989. Flows consist of cooling water from cooling tower blowdown and clean once-through cooling water.

Partek Insulation Ltd., Sarnia

Partek Insulation Ltd. is located in Sarnia. The plant has one effluent discharge into the Scott Road storm ditch. It manufactures fibre insulation materials for use as roof and pipe insulation, insulating block boards and blankets, wool and marine insulation.

Fibre insulation is manufactured when slag and basalt rock are mixed with coke and melted at approximately 1400 degrees Celsius in a furnace. The molten charge is then formed into fibres and cooled. Various chemical agents are added to the fibre to impart specific physical qualities, such as greater structural rigidity and dust suppression abilities. The fibres are sent to a blow-chamber where they are drawn to produce wool blankets of various thickness. Batt and industrial felt products are then cut from these blankets. Loose wool products are also manufactured at this facility.

Intake water is supplied from the city of Sarnia at a rate of approximately 265 m^3/d (68,900 U.S. gal/d).

Wastewater from the cupola cooling water, wastewater generated from floor washings, and product over-spray is sent to a retention pond for recycling back into the process. A small once-through cooling water stream combines with runoff water and discharges to the Scott Road Ditch. A number of raw materials such as coke, basalt rock, and slag, are stored in an open area, and are a potential source of storm water contamination (OMOE 1989d).

There have been no Environment Canada or OMOE studies of effluent discharges from this facility.

Welland Chemical Ltd., Sarnia

Welland Chemical Ltd. is located on Scott Road in Sarnia. The plant manufactures anhydrous aluminum chloride, sodium hypochlorite and packages chlorine gas. The facility has two batch and three once-through cooling water discharges to the Scott Road Ditch which drains to Talfourd Creek.

Aluminum chloride is produced by melting aluminum ingots in a furnace and passing gaseous chlorine through the melt. The gaseous aluminum chloride is then condensed and crystallizes on the condenser walls. These crystals are removed periodically for crushing, screening and packaging.

Chlorine is received in tank cars and re-packaged into 68 kg cylinders and 1 tonne containers. The cylinders and containers are degassed and steam cleaned on the site before they are filled.

Sodium hypochlorite solution is also produced by directing residual chlorine to caustic reactors to produce a 15 percent sodium hypochlorite solution. This solution is packaged into small plastic containers for distribution.

Aluminum chloride is used as a catalyst in the petroleum, pharmaceutical and other related industries. Chlorine is used for purifying water, in the manufacture of chlorinated hydrocarbons, plastics and other chemicals. Sodium hypochlorite is used as a bleach and disinfectant.

Intake water is supplied from the city at a rate of approximately 14 m^3/d (3,640 U.S. gal/d).

Water is used to vaporize liquid chlorine and for the washdown of the chlorine packaging areas and sodium hypochlorite plants. Once-through cooling water is used for compressor and condenser cooling.

There are four lagoons on site for wastewater. The south lagoon accepts wash water from the packaging, bulk loading and shipping areas. After treatment, this lagoon is pumped out several times a year into the Scott Road Drain which drains to Talfourd Creek. Two lagoons, which are connected in series, accept wash water from the chlorine packaging plant. The second lagoon is batch discharged to the Scott Road Drain/Talfourd Creek. All stormwater on the site drains into one of the four lagoons.

There is presently no OMOE monitoring requirement for this facility. There have been no Environment Canada nor OMOE studies of effluent from this plant (OMOE 1989d).

Standard Aggregate, Sarnia

Standard Aggregate is an aggregate (i.e. sand and gravel) handling and transfer station located on the shore of the St. Clair River between the city of Sarnia and Esso Petroleum Canada. Standard Aggregate operates on the site of the former Mueller Brass Foundry Company whose facilities have been removed.

Discharges or runoff from this site are not considered to be significant.

8.2.4.1.5 Thermal Generating Sector

The description of the thermal generating sector facility is based on its 1991 status.

Ontario Hydro Lambton Thermal Generating Station, Courtright

The Ontario Hydro Lambton Thermal Generating Station (Lambton TGS) is located south of Courtright on the St. Clair River. It is a coal-fired facility which came on-line in 1969 and 1970. Total station capacity is 2,000,000 kilowatts.

The plant has three separate water systems, a closed system within the plant to produce steam, a once-through cooling system which utilizes 8,400 X 10^3 m^3/d (2.18 X 10^6 U.S. gal/d) of water from the St. Clair River, and a boiler-bottom ash sluice. Water used for steam production is treated by pH adjustment, settling and filtration. Backwash from the water treatment is neutralized and then combined with the boiler-bottom ash sluice to be discharged into settling basins and subsequent filtering. The discharge from the filters is directed to the once-through cooling water sewer. Runoff from the coal pile is collected and pumped to the on-site ash disposal pond. The ash disposal pond is siphoned to a ditch which runs along the perimeter of the site to the St. Clair River.

Effluent Quality

Loading data for regularly monitored parameters at the Ontario Hydro Lambton Thermal Generating Station, Courtright, are shown in Table 8.29. These data include the annual net averages with the number of monthly exceedences in parenthesis for the monitored parameters, from 1986 through 1989.

Table 8.29 Annual average net loadings in kg/day and exceedences (# of months) of parameters under control at the Ontario Hydro Thermal Generating Station, Courtright, 1986 through 1989 (OMOE 1990c, 1989b, 1988c and 1987b).

Parameter	1989[1]	1988[2]	1987[3]	1986[4]
Flow (1000 m^3/day)	3000	2000	8037	7210
Water Temperature (degrees Celsius)	25.00 (0)	25.60 (2)	25.45 (2)	24.70 (0)
Temperature Rise (degrees Celsius)	14.9 (1)	14.1 (3)	14.3 (0)	14.0 (1)
Total Suspended Solids (kg/day)	773 14,862 Gross	0* (0)	95,790 (0)	0* (0)

0* Indicates intake exceeded discharge

1 1989 data from OMOE 1990c
2 1988 data from OMOE 1989b
3 1987 data from OMOE 1988c
4 1986 data from OMOE 1987b

The cooling water discharge is subject to limitations (Guidelines) for a rise in temperature of 16.7° C and a maximum effluent temperature of 32.2 C. These limits were exceeded 2 percent of the time in 1984, due mainly to high intake water temperatures in August and September. The maximum temperature limit was exceeded 0.02 percent of the time in 1985 (OMOE 1990b). Table 8.29 shows that maximum temperature exceedences occur in the summer months, twice per year. Table 8.29 also shows that the temperature increase was exceeded on three occasions (January, February and March) in 1988. There was only one exceedence for temperature rise in 1989 (March) and none for average monthly temperature.

8.2.4.1.6 Summary of 1988/89 Loadings and Guideline Compliance

The self-monitoring loadings data contained within the Industrial Dischargers Reports for 1986 through 1989 (OMOE 1987b, 1988c, 1989b and 1990c) were discussed in the preceding sections for each industrial point source. The most recent data (1988 or 1989) are summarized in Table 8.30 in order to compare among the various facilities. The number of monthly exceedences for controlled parameters at these 12 facilities are also indicated. All data are net with the exception of ICI Nitrogen Products, Fiberglas Canada, Ethyl and Novacor Chemical (Canada) Ltd.

Table 8.30 Average annual net loadings in kg/day and exceedences (# of months) of parameters under control (CofA) at Sarnia area industrial facilities during 1988 or 1989[1] (OMOE 1990c).

Facility	Flow (m^3/d)	NH3-N	Phenols	Suspended Solids	Oil and Grease	Total Organic Carbon	Lead	Total Kjeldahl Nitrogen	Total Phos-phorus
PETROLEUM REFINING									
Esso Petroleum Canada	217010	7.02(0)	0.130(0)	0[2](0)	30.60(0)	67.6(NA)	-	-	-
Novacor Chemicals, Corunna	4850	5.17(0)	0.023(0)	21.7(0)	1.25(0)	34.4(NA)	-	-	-
Shell Canada Products Ltd.	230190	16.57(0)	0.099(0)	210.0(0)	8.15(0)	249.0(NA)	-	-	-
Suncor Inc., Sunoco Division	96660	17.50(0)	0.188(0)	219.0(0)	45.60(0)	157.0(NA)	-	-	-
ORGANIC CHEMICALS									
Dow Chemical Canada Inc.	762670	-	1.300(0)	2413.0(0)	-	239.0(NA)	-	-	-
DuPont Canada Inc.	49100	-	0.090(0)	-	-	-	-	-	-
Esso Chemical Canada	30410	11.50(0)	0.032(0)	154.0(0)	7.37(0)	162.0(NA)	-	-	-
Ethyl Canada Inc.	35374	-	-	-	-	-	8.71(0)	-	-
Novacor Chemicals, Mooretown	1500	-	-	21.9(3)	-	11.6(NA)	-	1.59(NA)	0.477(0)
Polysar/Novacor Chemicals	364700	12.20(0)	0.500(0)	0[2]	(0)	3.68(0)	773.0(NA)	-	-
INORGANIC CHEMICALS									
I.C.I. Nitrogen Products	355859	226.00(0)	-	-	-	-	-	-	3.910(0)
Fiberglas Canada Inc.	4690	-	0.085(0)	-	-	-	-	-	-
THERMAL GENERATING SECTION									
Lambton Generating Station	3000000	-	-	773.0	-	-	-	-	-

- = not monitored
NA = not applicable
[1] Petroleum Refining Sector facilities and Esso Chemical Canada data are 1988, remainder are 1989.
[2] Intake concentration greater than discharge.

8.2.4.1.7 Results of Point Source Surveys for Ontario Industrial Point Sources

Data reviewed in this section include the results of three specific point source surveys conducted from 1985 to 1986/87. These surveys generally included a wide variety of organic parameters and metals which are not regularly monitored as requirements of Control Orders or Certificates of Approval. MISA monitoring data for more recent years includes many of these parameters and will be incorporated as they become available. There is a wide variability among the studies in terms of parameters analyzed, sample collection protocols and methods of analysis. However, the data are sufficient to provide some guidance in terms of trends, major sources and possible remedial issues.

Table 8.31 compares data presented in three separate surveys. The 1985 data were collected and reported by Environment Canada and OMOE (Environment Canada/OMOE 1986), the 1986 data were collected by the Point Source Workgroup of the UGLCCS (1988) and the 1986/87 data were collected under the Municipal-Industrial Strategy for Abatement (MISA) St. Clair River Pilot Site Investigation (OMOE 1990a).

The 1985 data were collected in late November under a cooperative federal/provincial effort established specifically to address the issue of the perchloroethylene/carbon tetrachloride puddles found during the summer of 1985 along the bed of the St. Clair River offshore of Dow Chemical (Environment Canada/OMOE 1986). The point source survey was limited to single samples collected at the outfall of the Cole Drain, at each of the major Dow sewers, Esso Petroleum, Esso Petrochemical, Scott Road Landfill, Sarnia WPCP and each major Polysar/Novacor sewer. Analyses were undertaken for several volatile organic and chlorinated organic compounds known to be discharged by local industries (Table 8.31).

The point source data collected in 1985 for this study concluded that there appeared to be some improvement compared with historical organics data collected in 1979/80.

UGLCCS (1988) included point source sampling of 16 major industries in the Sarnia area as well as U.S. and Canadian WPCPs. The point source data collected at Canadian facilities were collected during 3 to 6 day surveys carried out in May, June and September to December 1986. It should be noted that improvements in the treatment of industrial wastewater is ongoing and, hence, the data presented in Table 8.31 do not reflect improved effluent quality resulting from recent upgrading of treatment facilities at selected companies (see previous company descriptions).

Overall, the UGLCCS study found industrial loadings to be greater than municipal loadings for most parameters studied. The predominant sources were the petrochemical plants in the 'Chemical Valley' area south of Sarnia, Ontario. The majority of the sources were located in the upper 10 km (6.2 mi) of the St. Clair River. These industrial sources were found to be the source of the majority of the loadings of hexachlorobenzene, octachlorostyrene, PAHs, oil and grease, lead, mercury, copper, nickel, cobalt, iron, chromium, chlorides, total organic carbon (TOC), total suspended solids (TSS), and a spectrum of organic contaminants including volatile hydrocarbons, as well as acid and other base neutral extractables. In terms of effluent loadings, the following Ontario facilities were considered to be the principal contributors of one or more of the parameters studied.

Sarnia WPCP	-phenols, nickel, phosphorus, ammonia,cadmium and zinc.
Cole Drain	-PAHs, oil and grease, and cyanide.
Polysar/Novacor	-benzene, phenols, cobalt, and ammonia.
Dow Chemical	-hexachlorobenzene, octachlorostyrene, PCBs, copper, mercury, and volatiles.
Suncor	-volatile aromatics (associated with a process upset at the time of the survey).
Ethyl Canada	-lead, mercury, volatiles (chloroethane).
ICI	-iron, TSS, and chromium.

Table 8.31 Summary of loadings data from major point sources in Ontario, discharging to the St. Clair River (kg/d) from 1985 to 1987. Data for 1986 are net loadings whereas 1985 and 1986/87 data are gross loadings.

Parameter	Principal Sources	1985[a]	1986[b]	1986/87[c]
Organic Contaminants				
1,1-Dichloroethane	Cole Drain Dow Chemical[1] Polysar[2]	0.504 5.090		0.0576 4.6180 0.0030
1,2-Dichloroethane	Cole Drain Dow Chemical Polysar	8.96 10.65		0.0318 6.3596 0.0030
1,1,1-Trichloroethane	Cole Drain Dow Chemical Polysar	ND 7.670		0.1311 5.1330 0.0130
1,1,2-Trichloroethane	Cole Drain Dow Chemical Polysar	0.784 3.563		0.0020 0.8891 0.0180
2,4,5-Trichlorotoluene	Cole Drain Dow Chemical Polysar			0.0095 0.0522 ND
Benzene	Cole Drain Dow Chemical Polysar	ND 61.996 112.000		0.0040 0.6274 25.075
Carbon Tetrachloride	Cole Drain Dow Chemical Polysar	ND 25.709		0.008 4.087 0.003
Tetrachloroethylene	Cole Drain Dow Chemical Polysar	0.462 14.183		0.0477 3.0538 0.0070
Total Volatiles	Cole Drain Dow Chemical Polysar Ethyl Canada	15.5 242 115	 51.0 124.0 43.2	1.605 31.409
Octachlorostyrene	Cole Drain Dow Chemical Polysar	0.0006 0.0048	 0.0047	0.0092 0.0041 0.0002
Pentachlorobenzene	Cole Drain Dow Chemical Polysar	0.0032 0.0048		0.0091 0.0010 ND
Hexachlorobenzene	Cole Drain Dow Chemical Polysar	0.0025 0.125	0.0005 0.0300 0.0016	0.0089 0.012 ND
Hexachlorobutadiene	Cole Drain Dow Chemical Polysar			0.140 0.042 0.001

Table 8.31 (cont'd)

Parameter	Principal Sources	1985[a]	1986[b]	1986/87[c]
Total PAHs	Cole Drain		0.1720	
	Polysar		0.1630	
	Sarnia WPCP		0.1180	
	Ethyl Canada		0.0448	
	Suncor		0.0199	
Total PCBs	Dow Chemical	ND	0.0032	
	Polysar	ND	ND	
Metals and Conventional Pollutants				
Ammonia-nitrogen	ICI		256	
	Polysar		350	
	Sarnia WPCP		633	
Phosphorus-P	Sarnia WPCP		43.6	
Total Cyanide	Cole Drain		0.539	
	Polysar Sarnia		0.163	
Total Suspended Solids	Cole Drain			3061
	Dow Chemical			7046
	Polysar			1882
	ICI		4980	
Oil and Grease	Cole Drain		1300	
Total Phenols	Cole Drain		0.88	
	Dow Chemical		1.78	
	Polysar		1.08	
	Pt. Edward WPCP		1.69	
	Sarnia WPCP		4.32	
	Suncor		0.93	
Total Cadmium	Cole Drain			0.0465
	Dow Chemical			0.0041
	Polysar			0.0033
	Sarnia WPCP		0.137	
Total Chromium	ICI		8.92	
	Novacor Chemicals		2.50	
Total Copper	Cole Drain		1.22	
	Dow Chemical		6.24	
	Sarnia WPCP		1.53	
Total Iron	ICI		209	
	Sarnia WPCP		137	
Total Lead	Cole Drain			0.385
	Dow Chemical		8.3	0.514
	Polysar		1.7	0.082
	Ethyl Canada		19.1	
Total Mercury	Cole Drain			0.0022
	Dow Chemical		0.0287	0.0163
	Polysar			0.0004

Table 8.31 (cont'd)

Parameter	Principal Sources	1985[a]	1986[b]	1986/87[c]
Total Nickel	Dow Chemical Polysar Sarnia WPCP		0.644 0.657 0.973	
Total Zinc	Dow Chemical Sarnia WPCP		10.0 19.7	

ND = below detection.
a 1985 data from Environment Canada/OMOE (1986).
b August 1986 data from Point Source Workgroup (1988).
c May 1986 to March 1987 data from MISA Pilot Site Investigation (OMOE 1990a).
1 Dow Chemical for 1985 and 1986/87 data are the sum of the following outfalls: 1st St. 42"; 1st St. 48"; 1st St. 30"; 1st St. 54"; 2nd St.; 3rd St.; and 4th St. Sewers.
2 Polysar data for 1986/87 are the sum of outfalls 220 and 620.

The MISA Pilot Site Investigation was conducted between May 1986 and March 1987 (OMOE 1990a) investigated the presence and effects of 66 organic compounds and metals in the final discharges from six sewers at Dow Chemical Canada Inc., two outfalls at Polysar/Novacor (Sarnia) and the Cole Drain (Table 8.31).

The MISA Pilot Site Investigation focused its analysis and recommendations on eight 'parameters of potential concern': carbon tetrachloride; tetrachloroethylene; hexachlorobenzene; hexachlorobutadiene; hexachloroethane; octachlorostyrene; 2,4,5-trichlorotoluene and mercury. These chemicals were chosen on the basis that they are intermediate, or end products from organic chemical manufacturing processes; are consistently detectable in effluents discharging to the St. Clair River; and most tend to bioaccumulate in aquatic organisms and have demonstrated potential mutagenic or carcinogenic activity in laboratory experiments (OMOE 1990a). Linkages and potential linkages between their discharge and aquatic ecosystem effects (water, biota and sediment) were investigated using field studies. Effluent limits (load allocations) for these eight parameters were established through the use of chemical fate and transport modelling (WASTOX - Water Quality Analysis Simulation for Toxics), other sophisticated mathematical models and comprehensive sample collection.

In comparing the 1986/87 loadings data with the two earlier studies, it is evident that reductions had occurred for all organic parameters and mercury at all sources with the exception of the Cole Drain. Loadings of seven organic chemicals from this source were higher during 1986/87 than during 1985 (Table 8.31). The most notable reductions were observed for 1,1,2-trichloroethane, carbon tetrachloride, tetrachloroethylene, total volatiles and hexachlorobenzene at Dow Chemical as well as benzene at Polysar.

The report provided conclusions and recommendations with regard to waste load allocations, including mixing zone criteria; long term effluent monitoring; sampling and analytical methods based on the character of the effluents; and water, sediment and biomonitoring sampling protocols and conditions (OMOE 1990a).

The proposed allowable chemical-specific load allocations resulting from this study required reductions varying from not exceeding the loadings measured in 1986-87 to a 99.8 percent reduction for octachlorostyrene at the Cole Drain. Recommended reductions for the overall Dow complex were identified for hexachlorobenzene, 75 percent; octachlorostyrene, 99 percent; tetrachloroethylene, 39 percent; and hexachlorobutadiene, 13 percent (OMOE 1990a). As of 1990, based on preliminary results from the self-monitoring program, overall reductions in excess of 50 percent for hexachlorobenzene, 40 percent for octachlorostyrene, 62 percent for tetrachloroethylene and 50 percent for hexachlorobutadiene have been achieved (R. Denning, personal communication, February 1991).

Extensive effluent monitoring indicates that most sewers demonstrate highly variable effluent quality, with occasional peak discharges accounting for disproportionately high fractions of annual loadings. The MISA Pilot Site Investigation also recommended that remedial actions should focus on minimizing this variability, thereby assisting in achieving compliance with effluent guidelines (OMOE 1990a).

8.2.4.2 Michigan Industrial Point Sources

There are six major industrial dischargers to the St. Clair River in Michigan. The following sections describe the facilities, treatment processes, requirements of the NPDES permits, and the quality of the effluent discharged by each. Their locations are shown in Figure 8.1.

The major Michigan industries discharging to the St. Clair River are:

James River KVP, Port Huron
E.B.Eddy Paper (formerly Port Huron Paper), Port Huron
Detroit Edison Company, Marysville Station
Akzo Salt Incorporated (formerly Diamond Crystal Salt Company)
Detroit Edison Company, St. Clair Station
Detroit Edison Company, Belle River Station

The NPDES permits contain several special conditions which are indicated in Table 8.2.

Table 8.32 provides the estimated daily loadings to the St. Clair River and its tributaries for 1988 and 1989 from the six major Michigan industrial point source dischargers. The loadings were calculated using the monthly discharge monitoring reports (DMR) provided by the dischargers. The DMRs are based on self-monitoring requirements put forth in the individual NPDES permits (Appendix 8.1). Average daily loads were calculated in most cases. However, median loads were calculated when data for one or more months were reported in the DMR as below the analytical level of detection, not detected, or zero. Loadings provided in Table 8.32 are gross effluent loads. Although net loads would provide the most accurate indication of contaminant loadings generated by each facility, intake data, required in order to calculate net loads, were not available.

As in the case of Michigan municipal point sources (Section 8.2.3.2), the loadings were calculated based on average effluent flows and concentrations. In some cases, however, loadings are directly reported by the facility.

Akzo Salt Incorporated

Akzo Salt, Inc. (formerly Diamond Crystal Salt Company) produces sodium chloride products for domestic and industrial use. Process and cooling water is obtained from the St. Clair River. Process water is sand-filtered and chlorinated prior to use. Process wastewaters are from sand filter backwash, daily graveller and condenser cooling, continuous boiler blowdown and vacuum blowdown. All are discharged to a sedimentation tank for treatment. Sedimentation tank effluent is either recycled back underground for solution mining purposes or discharged to the outfall flume. The outfall flume discharges non-contact cooling water, treated process wastewater and stormwater to the St. Clair River via outfall 002 in compliance with the terms and conditions of NPDES Permit No. MI 0001031 issued August 23, 1990 (Appendix 8.1).

Final effluent limitations and monitoring requirements for this facility are listed in Table 8.33. Additional special permit requirements are shown in Table 8.2.

Table 8.32 Average daily 1988 and 1989 loading (kg/d) from the six major Michigan industrial facilities which discharge to the St. Clair River and its tributaries (Michigan Department of Natural Resources 1990).

Facility		Flow (MGD)	BOD_5	Suspended Solids	Total Phosphorus	Total Residual Chlorine	Oil and Grease	Chloride
Akzo Salt	-1988	1.70	-	36.00	-	-	-	30,868
	-1989	1.90	-	34.00	-	-	-	31,234
DECO Belle River								
St. Clair R.	-1988	627.30	-	1.00	-	-	0.29	-
	-1989	458.10	-	1.01	-	-	0.31	-
Belle River	-1988	9.67	-	235.30	-	-	1.80*	-
	-1989	9.52	-	309.40	-	-	1.20*	-
DECO Marysville	-1988	47.24	-	13.36	-	-	0.88*	-
	-1989	0.21	-	4.35*	-	-	0.42*	-
DECO St. Clair	-1988	920.80	-	312.70	-	260.00*	92.25	-
	-1989	1017.90	-	393.30	-	433.00	76.50	-
E.B. Eddy Paper								
St. Clair R.	-1988	-	-	-	-	-	-	-
	-1989	4.82	811	449.00	1.92	3.86	-	-
Black River	-1988	5.56	558	228.00	-	-	-	-
	-1989	1.83	503	274.00	-	-	-	-
James River KVP	-1988	2.59	155	264.00	-	-	-	-
	-1989	2.51	250	209.00	-	-	-	-

- = no data.
* one or more median values used in determing the load.

The NPDES permit of the AKZO Salt facility contains a special condition that requires the permittee to submit a biomonitoring plan for acute toxicity testing on the effluent from outfall 002. The plan was submitted on October 30, 1990. The plan is presently under review by Division staff.

Total suspended solids and chlorides are the only parameters of concern discharged from this facility. Loads to the St. Clair River from Akzo Salt for 1988 and 1989 are provided in Table 8.32.

The last Compliance Sampling Inspection (CSI), conducted on August 14-15, 1990 showed the facility was in compliance with its NPDES permit and the discharge did not contain any organic or inorganic contaminants at levels of concern.

Routine review of facility self-monitoring data and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of the NPDES permit.

Table 8.33 Akzo Salt, Inc. final effluent limitations and monitoring requirements. NPDES Permit Number MI 0001031, issued August 23, 1990.

OUTFALL	EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
		lbs/d (kg/d)		OTHER LIMITATIONS			
		Monthly Average	Daily Maximum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
Intake	Temperature(F)			(report)	(report)	Continuous	Report Daily Average
002	Flow (MGD)			(report)	9.0 34.1 (report)	Daily	Report Total Daily Flow
	Temperature(F)			(report)	(report)	Continuous	Report Daily Average
	Total Residual Chlorine (mg/l)			0.036	Daily	Grab	
	Outfall Observation			(report)	Daily	Visual	
	pH (Standard Units)			6.5[1]	9.0[2]	Daily	Grab
00A*	Flow (MGD)			(report)	(report)	Daily	Report Total Daily Flow
	Total Suspended Solids (mg/l)			(report)	(report)	Daily	24 hour Composite
	Total Suspended Solids	744 (338)	1303 (591)			Daily	Calculation
	Chlorides (mg/l)			(report)	(report)	Daily	24 hour Composite
00B*	Flow (MGD)			(report)	(report)	Daily	Report Total Daily Flow
	Chlorides (mg/l)			(report)	(report)	Daily	24 hour Composite
00A/00B combined	Chlorides		92,035 (41747)			Daily	Calculation

* Outfall 00A shall be defined as the overflow from the settling pit. Outfall 00B shall be defined as the discharge from the plant vacuum system.

[1] Daily Minimum
[2] Daily Maximum

Detroit Edison Company - Belle River Station

The Detroit Edison Company (DECO), Belle River Station is a coal fired, electric generating facility with a maximum output of 1352 megawatts. It has a maximum design flow of 1,000,000 MGD and an average daily flow of 411 MGD (1,556 X $10^3 m^3/d$).

The DECO-Belle River facility is located approximately 2 km (1.2 mi) inland, west of the St. Clair River. The plant takes its cooling and process water from the St. Clair River. Non-contact cooling water, boiler blowdown, and oily water treatment is handled by the Belle River plant treatment systems. The treated wastewater is discharged to the St. Clair River via outfall 001 through a submerged multiport diffuser. Bottom Ash transport water and low volume waste is discharged to the Belle River via Webster Drain via outfall 002.

The facility is regulated under NPDES Permit No. MI 0038172, issued September 21, 1989 (Appendix 8.1). A summary of the DECO-Belle River plant NPDES permit effluent limitations are listed in Table 8.34. Additional special permit requirements are shown in Table 8.2.

The NPDES permit of the DECO-Belle River facility contains a special condition that requires the permittee to conduct a Short-Term Waste Characterization Study for methylene chloride, lead, cadmium, selenium, and silver. These parameters were found in sampling results submitted by the company with their permit application. Monitoring required under this condition is designed to determine whether these constituents are discharged in significant quantities. Results of STWCS were submitted by the company April 14 , 1990.

The permittee is also required by the permit to undertake a study to reduce the discharge of settleable solids to the maximum extent practicable from outfall 002. The study shall include the investigation of alternative treatment technologies. Results of the study were submitted to the District office on January 4, 1991. The results are presently under review by District staff. A study of the intake structure to quantify entrainment and impingement of fish is also a requirement of the NPDES permit. The results of the study are to be submitted to the Chief of the Surface Water Quality Division, MDNR by July 1, 1991.

An Aquatic Toxicity Assessment was conducted on the effluent from both DECO-Belle River outfalls in January 1986. Test animals (*Daphnia magna*) remained alive and vigorous throughout the tests, and showed no signs of toxic effects.

Loads to the St. Clair River and the Belle River from The DECO-Belle River plant for 1988 and 1989 are provided in Table 8.32.

The last Compliance Sampling Inspection (CSI), conducted on July 29-30, 1986, showed the facility was in compliance with its NPDES permit and the discharge did not contain any organic or inorganic contaminants at levels of concern. The next sampling survey for this facility is scheduled for September 3-4, 1991.

Routine review of facility self-monitoring data and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of the NPDES permit.

Detroit Edison Company - Marysville Station

The Detroit Edison Company (DECO), Marysville Power Station is a coal fired, electric generating facility that generates power during peak load periods. The facility generates about 3500 megawatt hours per day and supplies an average of 2.4 million pounds (1,088.6 tonnes) of steam per day.

Table 8.34 Detroit Edison Company-Belle River Plant NPDES Permit final effluent limitations on discharges to the St. Clair River (Outfalls 001 and 00A) and Belle River (Outfalls 002, 003, 004 and 005). NPDES Permit No. MI0038172, issued September 21, 1989.

OUTFALL	EFFLUENT CHARACTERISTICS	DISCHARGE LIMITATIONS			MONITORING REQUIREMENTS	
		Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
001	Flow MGD* (X 10^3 m^3/d)	--	--	964 (3649)	Daily	Report Total Daily Flow
	Intake Temperature (F)	--	--	--	Daily	Direct Reading
	Discharge Temp.(F)	--	--	--	Daily	Direct Reading
	Heat Addition (BTU/hr)	--	7.0×10^9	--	Daily	Calculation
	Total Residual Chlorine (mg/l)	--	--	0.2	Daily Per Occurrence	Grabs (3 per treatment)
	Chlorine Discharge Time (min/day)	--	--	160	Daily Per Occurrence	
	pH (Standard Units)	6.5	--	9.0	Weekly	Grab
	Outfall Observation	--	--	Daily	Visual	
00A	Flow MGD* (X 10^3 m^3/d)	--	--	1.29 (4.9)	Daily	Report Total Daily Flow
	Total Suspended Solids (mg/l)	--	30	100	Weekly per Occurrence	Grab
	Oil & Grease (mg/l)	--	15	20	Weekly per Occurrence	Grab
002	Flow MGD* (X 10^3 m^3/d)	--	--	20.0 (75.7)	Daily	Report Total Daily Flow
	Temperature (F) January (effective 1/1/92) February (effective 1/1/92)	 -- --	 43 42	 -- --	 Daily Daily	 Direct Reading Direct Reading
	Total Suspended Solids (mg/l)	--	30	100	Weekly	24-Hr. Composite
	Oil & Grease (mg/l)	--	15	20	Weekly	Grab
	pH (Standard Units)	6.5	--	9.0	Weekly	Grab
	Outfall Observation	--	--	--	Daily	Visual
003, 004, 005	Outfall Observation	--	--	--	Weekly during discharge	Visual

* Flow is not a limitation on the quantity or rate of discharge.

Water for the DECO - Marysville facility is obtained from the St. Clair River. The total discharge to the St. Clair River is via the outlet canal, outfall 001, which receives all the wastewater from several wastewater sources. The chemical waste system treats boiler blowdown and metal cleaning wastes. Solids are settled out and the waste is treated with lime slurry until a predetermined pH is reached. The treated wastewater is discharged via the outlet canal. The ash waste system treats wastewater for the removal of bottom ash. The system includes four ash basins, polymer addition, and treatment in a gravity settler. Oily waste is pumped to an oily waste equalization basin, then to an oil-water separator and a pressure sand filter. The waste is then discharged to the outlet canal.

On May 1, 1988 the facility went on "Economy Reserve" and is not generating electricity at the present time. The only discharges at the present time include stormwater runoff and discharge from a small temporary boiler used to heat the plant buildings. Because of the possibilities of increased power needs in the future and the continued discharge of stormwater the facility is still regulated under NPDES Permit No. MI 0001694, issued on February 26, 1985 (Appendix 8.1). Final effluent limitations and monitoring requirements for this facility are listed in Table 8.35. Additional special permit requirements are shown in Table 8.2.

The NPDES permit of the DECO-Marysville facility contains a special condition that requires the permittee to conduct a Short-Term Waste Characterization Study for several volatile, acid and base/neutral compounds discharged from outfall 001. Zinc was detected in the effluent during a Sampling Survey. Monitoring required under this condition is designed to determine whether these constituents are discharged in significant quantities.

Loads to the St. Clair River from The DECO-Marysville plant for 1988 and 1989 are provided in Table 8.32.

The last Compliance Sampling Inspection (CSI), conducted on March 9-10, 1987, showed the facility was in compliance with its NPDES permit and the discharge did not contain any organic or inorganic contaminants at levels of concern.

Routine review of facility self-monitoring data and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of the NPDES permit.

Detroit Edison Company - St. Clair Station

The Detroit Edison Company (DECO), St. Clair Power Station is a oil/coal fired, electric generating facility with a maximum output of 1550 megawatts. The plant's seven generating units produce about one quarter of the power for the Detroit metropolitan area.

The majority of the water used at the plant is once through non-contact condenser cooling water, obtained from the St. Clair River. The cooling water is chlorinated for slime control and discharged to the St.Clair River via outfall 001. Other continuous and intermittent flows are discharged through outfall 001, from five main treatment systems. Possible oil contaminated wastewaters are routed to waste equalization basins, then pumped to gravity type parallel plate oil-water separators and finally to pressure sand filters for polishing prior to discharge. Treatment of boiler blowdown and metal cleaning wastes includes solids removal, pH adjustment and removal of metal precipitates. This wastewater is then discharged to outfall 001. Fly ash is sluiced to settling lagoons, solids settled by gravity and the overflows go to outfall 001. Bottom Ash is sluiced to two separate lagoons. Alum is added to the influent of the first lagoon to aid settling. Overflows from the second basin can be pumped to outfall 001 but normally goes through 002 to the St. Clair River. Coal pile runoff is collected and pumped to settling basins. Turbidity is monitored, and when acceptable, the overflow is pumped to outfall 001. Air scrubber water, miscellaneous cooling water and demineralizer regeneration wastewater flow to settling basins and are discharged to the Belle River or the St. Clair River. Water treatment wastewater, stormwater runoff, coal pile runoff, and chemical and non-chemical metal cleaning waste from the DECO-Belle River plant are also discharged through the St. Clair Plant outfalls.

Table 8.35 Detroit Edison Company-Marysville Plant NPDES Permit final effluent limitations on Outfall 001 discharge to the St. Clair River. NPDES Permit No. MI0001694, issued February 26, 1985.

Waste Type	Effluent Characteristic	Daily Maximum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
Noncontact cooling water; chemical and non-chemical metal cleaning; low volume wastes; bottom ash transport water; coal pile runoff	Flow, MGD* (X 10^3 m^3/d)	366.5 (1387.3)			Daily	24-Hr.Total
	Temperature (F) Intake Discharge**				Daily Daily	Reading Reading
	Heat Addition, BTU/hr.			1.8 x 10^9	Daily	Calculation
	Total Residual Chlorine (TRC)			0.2 mg/l	5 x weekly	3 grab samples spaced during discharge of chlorine
	Chlorine Discharge Time			160 min/day	5 x weekly	Report discharge time
	Outfall Observation				Daily	Visual
Chemical and non-chemical metal cleaning waste	Flow, MGD* (X10^3 m^3/d)	0.466 (1.8)			Daily***	24-Hr. Total
	Total Copper			1.0 mg/l+	Daily***	Grab+
	Total Iron			1.0 mg/l+	Daily***	Grab+
	Total Suspended Solids		30 mg/l	100 mg/l	Daily***	Grab
	Oil and Grease		15 mg/l	20 mg/l	2 x monthly**	Grab
Oily waste treatment effluent	Flow, MGD* (X 10^3 m^3/d)	0.640 (2.4)			Weekly	24-Hr. Total
	Total Suspended Solids		30 mg/l	100 mg/l	Weekly	Grab
	Oil and Grease		15 mg/l	20 mg/l	2 x monthly	Grab
Coal Pile Runoff	Flow, MGD				Daily***	
	Total Suspended Solids			50 mg/l	Daily***	Grab

* Flow is not to be considered as a limitation.

** The discharge after mixing with the St. Clair River shall not increase the temperature of the river more than 3 F above existing natural temperature, or above monthly temperatures as stated in the permit.

*** Per Occurrence

\+ Applies for the discharge of chemical metal cleaning wastes only.

The facility is regulated under NPDES Permit No. MI 0001686, issued on August 23, 1990 (Appendix 8.1). A summary of the DECO-St.Clair plant NPDES permit effluent limitations are listed in Table 8.36. Additional special permit requirements are shown in Table 8.2. The NPDES permit of the DECO-St.Clair facility contains a special condition that requires the permittee to conduct a Short-Term Waste Characterization Study (STWCS) for copper, lead, cadmium, amenable cyanide, selenium, silver and chromium for various outfalls. Lead was detected in the effluent during a 1986 Sampling Survey. Monitoring required under this condition is designed to determine whether these constituents are discharged in significant quantities. Results from the STWCS were submitted the District office on February 4, 1991. The submittal is presently under review by Division staff.

Loads to the St. Clair River and the Belle River from The DECO-St. Clair plant for 1988 and 1989 are provided in Table 8.32.

The last Compliance Sampling Inspection (CSI), conducted on July 29-30, 1986, showed the facility was in compliance with its NPDES permit and the discharge did not contain any organic or inorganic contaminants at levels of concern. The next sampling survey for this facility is scheduled for September 3-4, 1991.

Routine review of facility self-monitoring data and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of the NPDES permit.

E.B. Eddy Paper, Inc.

E.B. Eddy Paper, Inc. manufactures specialty papers from wood pulp and secondary fibers. The plant is rated at 400 tonnes/day (440 tons/day) of paper production. Cooling water and process water are obtained from the St.Clair River.

Process wastewater is treated by air flotation clarifiers and discharged, in combination with a portion of the non-contact cooling water, through outfall 009 to the St.Clair River. Additional non-contact cooling water and backwash from the intake sand filters is discharged through outfall 008 to the Black River. Both of these discharges are regulated under NPDES Permit MI0002160, issued July 21, 1988 and modified July 19, 1990 (Appendix 8.1). Monitoring requirements and final effluent limitations are shown in Table 8.37 and additional special conditions in the Permit are indicated in Table 8.2.

The effluent from E.B. Eddy Paper, Inc. was found to be acutely toxic during a July 1987 aquatic toxicity study. As a result of this study, the NPDES Permit required the company to conduct Acute Toxicity Testing of outfall 009 effluent. This testing was completed in 1989/1990 and the reports indicated that the effluent was toxic. In accordance with Rule 82 of the WQS, the facility has developed and submitted a Toxicity Identification/Reduction Evaluation (TI/RE) Plan. The Plan is currently under review by staff of the Surface Water Quality Division.

Parameters of concern discharged from this facility include total suspended solids, total phosphorus, cadmium, and total phenols. The last three parameters were detected at 25 $\mu g/l$, 14 $\mu g/l$ and in the June 26-27, 1990 Compliance Sampling Survey. The May 22-23, 1989 Compliance Sampling Survey did not indicate that the discharge contained any organic/inorganic parameters at levels of concern. The cadmium, total phenols, and other low level detected purgeable halocarbons and aromatic hydrocarbons will be reviewed by staff of the Surface Water Quality Division.

Loads to the St.Clair River from the E.B. Eddy Paper facility for 1988 and 1989 are provided in Table 8.32.

E.B. Eddy Paper, Inc. was issued a Notice of Non-compliance and a Notice of Violation in 1989 for discharges of "unnatural turbidity" from outfall 009 to the St.Clair River. The facility modified their treatment facilities to eliminate the discharge of white sulphur bacteria in 1990.

Table 8.36 Detroit Edison Company-St. Clair Plant NPDES Permit final effluent limitations on discharges to the St. Clair and Belle Rivers. NPDES Permit No. MI0001686, issued August 23, 1990.

OUTFALL	EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
				OTHER LIMITATIONS			
		Monthly Average	Daily Maximum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
001	Flow MGD* (X 10^3 m^3/d)	(report)	(report)	--	1395.0 (5280.5)	Daily	Report Total Daily Flow
	Temperature(F) Intake Discharge	-- --	-- --	-- --	(report) (report)	Daily Daily	Reading Reading
	Heat Addition, BTU/Hr.	--	--	--	8.3 x 10^9	Daily	Calculation
	Total Residual Chlorine (TRC)	--	--	--	0.2 mg/l	5 X Weekly	3 Grab Samples
	Chlorine Discharge Time	--	--	160	5 X Weekly min/day	Report	Discharge Time
	pH (Standard Units)			6.5[1]	9.0[2]	Weekly	Grab
	Outfall Observation**	--	--	--	Daily	Visual	
00A	Flow MGD* (X 10^3 m^3/d)	(report)	(report)	--	4.8 (18.2)	Per Occurrence	Report Total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	50 mg/l	Per Occurrence	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly Per Occurrence	Grab
008	Flow MGD* (X 10^3 m^3/d)	(report)	(report)	--	5.02 (19.0)	Per Occurrence	Report Total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	50 mg/l	Per Occurrence	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly Per Occurrence	Grab
	pH (Standard Units)	--	--	6.5[1]	9.0[2]	Per Occurrence	Grab
	Outfall Observation**	--	--	--		Per Occurrence	Visual
00B	Flow MGD* (X 10^3 m^3/d)	(report)	(report)	--	0.80 (3.03)	Per Occurrence	Report total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	100 mg/l	Per Occurrence	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly Per Occurrence	Grab
	Total Iron***	--	--	--	1.0 mg/l	Per Occurrence	Grab
	Total Copper***	--	--	--	1.0 mg/l	Per Occurrence	Grab
00C	Flow MGD* (X 10^3 m^3/d)	(report)	(report)	--	1.4 (5.3)	Per Occurrence	Report Total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	100 mg/l	Weekly Per Occurrence	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly Occurrence	Grab
00D	Flow MGD* (X 10^3 m^3/d)	(report)	(report)	--	8.30 (31.4)	Twice Weekly	Report Total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	100 mg/l	Weekly	24 Hour Composite
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly	Grab

Table 8.36 (cont'd)

OUTFALL	EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
				OTHER LIMITATIONS			
		Monthly Average	Daily Maximum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
002	Flow MGD* ($X 10^3 m^3/d$)	(report)	(report)	--	19.50 (73.8)	2 X Weekly	Report Total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	100 mg/l	Weekly	24 Hour Composite
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly	Grab
	pH (Standard Units)			6.5[1]	9.0[2]	2 X Weekly	Grab
	Outfall Observation**	--	--	--	2 X Weekly	Visual	
00E	Flow MGD* ($X 10^3 m^3/d$)	(report)	(report)		0.60 (2.3)	Weekly	Report Total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	100 mg/l	Weekly	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly	Grab
009	Flow MGD* ($X 10^3 m^3/d$)	(report)	(report)	--	2.30 (8.7)	Weekly	Report Total Daily Flow
	Total Suspended Solids	--	--	30 mg/l	100 mg/l	Weekly	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly	Grab
	pH (Standard Units)			6.5[1]	9.0[1]	Weekly	Grab
	Outfall Observation**	--	--	--	Weekly	Visual	
00F	Flow MGD* ($X 10^3 m^3/d$)	(report)	(report)		3.5 (13.2)	2 X Weekly	Report Total Daily Flow
	Total Suspended Solids		--	30 mg/l	100 mg/l	Weekly Per Occurrence	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly Per Occurrence	Grab
00G	Flow MGD* ($X 10^3 m^3/d$)	(report)	(report)	--	0.190 (0.72)	Weekly	Report Total Daily Flow
	Total Suspended Solids		--	30 mg/l	100 mg/l	Weekly	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly	Grab
00H	Flow MGD* ($X 10^3 m^3/d$)	(report)	(report)	--	1.70 (6.4)	Per Occurrence	Report Total Daily Flow
	Total Suspended Solids		--	30 mg/l	100 mg/l	Weekly Per Occurrence	Grab
	Oil and Grease	--	--	15 mg/l	20 mg/l	2 X Monthly Per Occurrence	Grab
007	Outfall Observation**	--	--	--	--	Weekly During Discharge	Visual Observation

* The flow is not to be considered as a limitation on either the quantity or rate over time of discharge.

** Any unusual characteristics of the discharge (i.e., unnatural turbidity, colour, oil film, floating solids, foams, settleable solids, or deposits which would not be expected from the discharge above) shall be reported immediately to the Detroit District Supervisor of the Surface Water Quality Division followed with a written report within five days detailing the findings of the investigation and the steps taken to correct the condition.

*** The monitoring requirements and limits for iron and copper only apply for the discharge of chemical metal cleaning wastes.

1 Daily Minimum

2 Daily Maximum

Table 8.37 E.B. Eddy Paper, Inc. NPDES final effluent limitations on discharges to the Black River (Outfall 008) and St. Clair River (Outfall 009). NPDES Permit No. MI0002160, issued July 21, 1988.

OUTFALL (Dates in Effect)	EFFLUENT CHARACTERISTIC	lbs/d (kg/d)		OTHER LIMITATIONS		MONITORING REQUIREMENTS	
		Monthly Average	Daily Maximum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
008 (7/21/88-8/31/89)	Flow MGD (X 10^3 m^3/d)	-	-	-	14.4 (54.5)	Daily	Report Total Daily Flow
	Total Suspended Solids	1706 (774)	2511 (1139)	-	-	Daily	24-hr. Composite
	Total BOD5	1823 (827)	2734 (1240)	-	-	Daily	24-hr. Composite
	pH (Standard Units)			6.0[1]	9.0[2]	Daily	Grab
	Outfall Observ.	-	-	-	-	Daily	Visual
008 (9/1/89-6/30/93)	Flow MGD (X 10^3 m^3/d)	-	-	-	1.6 (6.1)	Daily	Report Total Daily Flow
	Total Suspended Solids	-	-	-	75 mg/l	Daily	24-hr. Composite
	pH (Standard Units)			6.5[1]	9.0[2]	Daily	Grab
	Outfall Observ.	-	-	-	-	Daily	Visual
009 (9/1/89-6/30/93)	Flow MGD (X 10^3 m^3/d)	-	-	-	8.0 (30.3)	Daily	Report Total Daily Flow
	Total Suspended Solids	3308 (1501)	6207 (2816)	-	-	Daily	24-hr. Composite
	BOD5	3887 (1763)	6954 (3154)	-	-	Daily	24-hr. Composite
	Total Residual Chlorine	-	-	-	0.036 mg/l	Daily	Grab
	Total Phosphorus	-	-	1.0 mg/l	-	Weekly	24-hr. Composite
	pH (Standard Units)			6.0[1]	9.0[2]	Daily	Grab

Routine review of facility self-monitoring reports and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of their NPDES Permit. The facility has had periodic non-compliances with pH limitations during 1990 and the District compliance staff has initiated administrative compliance action against the facility to cause correction of these problems.

James River KVP, Port Huron

James River KVP-Port Huron produces light weight and Kraft specialty papers from recycled and virgin fibers. The facility has an average production rate of 160 to 170 tonnes (176.3 to 187.3 tons) of paper per day. Cooling water and a portion of the process water is obtained from the St.Clair River.

Process wastewaters are treated by three Save-Alls. The effluent from these three units, along with felt shower water, press water, and miscellaneous process flows, is discharged to two parallel air flotation clarifiers. Recovered fibers are either recycled or landfilled. The treated process wastewater, combined with cooling water, storm water drainage, and microstrainer backwash, is discharged to the St.Clair River at an average volume of 2.8 MGD (10.6 X $10^3 m^3/d$) under regulation of NPDES Permit MI0003450, issued May 24, 1990 (Appendix 8.1). The established effluent limitations and monitoring conditions are shown in Table 8.38. Additional special permit requirements are shown in Table 8.2.

Table 8.38 James River KVP-Port Huron Facility NPDES final effluent limitations and monitoring requirements. NPDES Permit Number MI0003450, issued May 24, 1990.

OUTFALL	EFFLUENT CHARACTERISTICS	DISCHARGE LIMITATIONS (lbs/d & kg/d)		DISCHARGE LIMITATIONS OTHER LIMITATIONS		MONITORING REQUIREMENTS	
		Monthly Average	Daily Maximum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
001	Flow, MGD (X $10^3 m^3$)	(report)	(report)	--	3.5 (13.2)	Daily	Report Total Daily Flow
	Total Copper	--	--	--	44 ug/l	Weekly	24-Hr. Comp.
	Temperature(F)	--	--	--	--	Weekly	Direct Reading
	Outfall Observation*	--	--	--		Daily	Visual Observation
00A**	Flow, (MGD) (X $10^3 m^3$)	(report)	(report)	--	3.14 (11.9)	Daily	Report Total Daily Flow
	BOD_5	1,719	2,829	--	--	Daily	24-Hr. Composite
	Total Suspended Solids	1,462	2,895	--	--	Daily	24-Hr. Composite
	pH (Standard Units)			6.5[1]	9.0[2]	Daily	Grab
00B**	Total Suspended Solids	--	180	--	--	Daily During Discharge	24 Hr. Composite
	Intake Nonsettleable Solids	--	--	--	--	Daily During Discharge	24 Hr. Composite

* The receiving stream shall contain no unnatural turbidity, colour, oil film, floating solids, foams, settleable solids, or deposits as a result of this discharge.
** Internal outfalls. Discharge is through outfall 001 to the St. Clair River.

[1] Daily Minimum
[2] Daily Maximum

Due to the results of Toxicity Testing conducted in 1987 and 1989, James River KVP was required to conduct Acute Toxicity Testing as part of their NPDES Permit. The Toxicity Testing was completed in February of 1990 and the effluent is within the requirements of Rule 82 of the WQS.

A Short Term Wastewater Characterization Study (STWCS) was required in the NPDES Permit to provide additional information on possible total residual chlorine in the effluent. The data for the total chlorine residual STWCS was submitted October 10, 1990 and is currently under review.

Total suspended solids and total copper are the two parameters of concern discharged from this facility. Copper was detected in effluent sampling performed by the facility during their permit reapplication process, thus it was incorporated into the NPDES Permit. Loads to the St.Clair River from James River KVP for 1988 and 1989 are provided in Table 8.32.

Compliance Sampling Surveys were conducted at James River KVP on May 22-23, 1989 and June 26-27, 1990. The results of these surveys showed that the facility was in compliance with its NPDES permit and the discharge did not contain any organic or inorganic contaminants at a level of concern.

Routine review of facility self-monitoring reports and periodic inspections by District personnel indicate that the facility is in substantial compliance with the terms and conditions of its NPDES Permit. During October 1990 and December 1990 the facility failed to meet its 44 μg/l daily maximum for total copper with one out of four samples in each month exceeding the limitation at 50 μ/l. District compliance staff is reviewing this data for possible administrative compliance action.

8.3 NONPOINT SOURCES

8.3.1 Waste Disposal Sites and Landfills

Waste disposal sites and landfills are potential sources of groundwater contamination. Groundwater is a nonpoint source of pollutants to the St. Clair River. In this section, groundwater flow surveys are discussed. Waste disposal and landfill site descriptions and their status as a source of groundwater or surface water contamination are reviewed, however, contaminant loads from both the Ontario and Michigan contaminated sites have not been measured.

Three different groundwater flow systems contribute to the overall groundwater discharge. These include:

- Discharge from surficial aquifers;
- Discharge from intermediate flow systems; and
- Discharge from deep bedrock systems.

Groundwater in the unconsolidated surficial deposits generally flows to the St. Clair River. Locally, however, the direction of groundwater flow is influenced by surface water drainage and glacial landforms. Groundwater flow directions in the deeper units are as yet not well defined.

Total groundwater seepage directly to the St. Clair River was estimated by three independent teams of investigators to range between 55,728 m^3/d (14.5 X 10^6 U.S. gal/d) and 64,002 m^3/d (16.6 X 10^6 U.S. gal/d) and to average about 60,480 m^3/d (15.7 X 10^6 U.S. gal/d) (UGLCCS 1988). The U.S. Geological Survey estimated total groundwater discharge to the river from groundwater discharge areas, based upon tributary baseflow information. The University of Wisconsin - Milwaukee used a combined geophysical and hydrological method to compile continuous measurements of groundwater flow passing through the St. Clair River bed. The University of Windsor Great Lakes Institute deployed seepage metres and mini-piezometers to measure seepage in the Sarnia area (UGLCCS 1988). Although the estimates are similar, there is some uncertainty in the numbers, as groundwater flow is difficult to accurately measure in large river systems.

Groundwater which does not discharge directly to the St. Clair River contributes to stream flow of tributaries of the St. Clair River. Groundwater within the area immediately adjacent to the St. Clair River contributes about 10 percent of the tributary flow (UGLCCS 1988). Rates of groundwater seepage to the St. Clair River generally decreased downstream, with higher flows noted in the Sarnia and Port Huron area, and between Stag Island and Courtright, coinciding with areas having the largest number of potential sources of groundwater contamination.

Although the total amount of discharge to the St. Clair River is small relative to the St. Clair River's water budget, the heterogeneities that are apparent in the nature and the distribution of groundwater flow suggest that inputs of contaminated groundwater may be locally significant (UGLCCS 1988).

8.3.1.1 Ontario (Sarnia) Manufactured Gas Plant Site

During 1986, buried wastes were discovered at the site of a former manufactured gas plant in Ottawa, Ontario. Manufactured gas plants produced gas for illumination and heat in Ontario for over 100 years from about 1850 to the late 1950s, mostly by carbonization of coal. In addition to combustible gas, these plants produced by-products, such as tars, sludge, liquors and other gas-cleaning wastes, much of which were left in buried containers at the plant site or transported to waste disposal sites. These wastes are environmentally hazardous because they contain PAHs, phenols, light aromatics, cyanide, inorganic sulphur and nitrogen species and trace metals.

The discovery of these wastes prompted OMOE to commission a study to identify and provide a preliminary assessment of manufactured gas plant sites in the Province of Ontario. This report by Intera Technologies Ltd. (1987) identified forty-one sites possibly containing hazardous coal tar wastes one of which is located on Maxwell St., Sarnia. This gas plant was in operation for 25 years between 1884 and 1909.

The Sarnia gas plant site is currently owned by Sarnia Hydro, which operates a hydro-electric substation on the site. The site is only 125 m (410 ft) east of the St. Clair River. Adjacent land use is commercial/residential and recreational. A site inspection did not detect odours or contaminated seepage. Waste materials were not reported in excavations in the area of Water, Maxwell and Front Streets during the construction of storm and sanitary sewers and watermains.

In 1989, Conestoga-Rovers and Associates conducted a study of the old gas manufacturing site in order to determine the contaminants present, their distribution, and potential for groundwater and air contamination. Coal tar non-aqueous pollutant load (NAPL, refers the that portion of coal tar which is not dissolved in groundwater and can be visually identified as a separate and distinct material) was found to have saturated sands in the glaciolacustrine deposit over the southern two-thirds of the site. These sands are up to 2.4 m (7.9 ft) thick and overlie a glacial till that inhibits vertical movement of coal tar. Off-site contamination was not found.

Currently, coal tar NAPL on-site is sufficiently covered by 0.4 to 2.0 m (1.3 to 6.6 ft) of fill to prevent exposure of the waste through existing on-site activities. Data also indicate that air quality above the site is not affected.

Groundwater in the glaciolacustrine deposits on the site has been impacted by coal tar NAPL. Horizontal groundwater flow was calculated to be 0.47 m/yr towards the St. Clair River. Travel time to the river was determined to be 200 to 300 years, and over 100 years have already passed since the plant first started operations. The groundwater is not used for drinking water and thus does not represent a direct threat to human health (OMOE 1989e).

A more recent survey conducted by Beak Consultants for OMOE and the Sarnia-Clearwater Hydro Commission at Centennial Park has not found evidence of coal tar beneath the park. Centennial Park is located between the river and the site of the former gas plant. This report did, however, discover the presence of PAHs in groundwater under the park. The source of the PAHs and their impact to the St. Clair River is not known.

8.3.1.2 Ontario Waste Disposal Sites, Landfills and Injection Wells

On the Ontario side of the St. Clair River, a total of 21 industrial and 2 municipal waste sites and landfills have been identified in close proximity to the St. Clair River. As discussed earlier, groundwater seepage discharge rates are highest at the head of the river, in the Sarnia-Port Huron area and from Stag Island to Courtright. The majority of the industrial waste disposal and landfill sites are located in these areas.

Industrial waste disposal and landfill sites and their current status are listed in Table 8.39 together with other local wastes sites of concern. The location of the sites is shown in Figure 8.4. The sites listed in Table 8.39 and their potential for contamination are individually described below.

Table 8.39 Ontario industrial and municipal waste disposal and landfills in the vicinity of the St. Clair River and their current operating status.

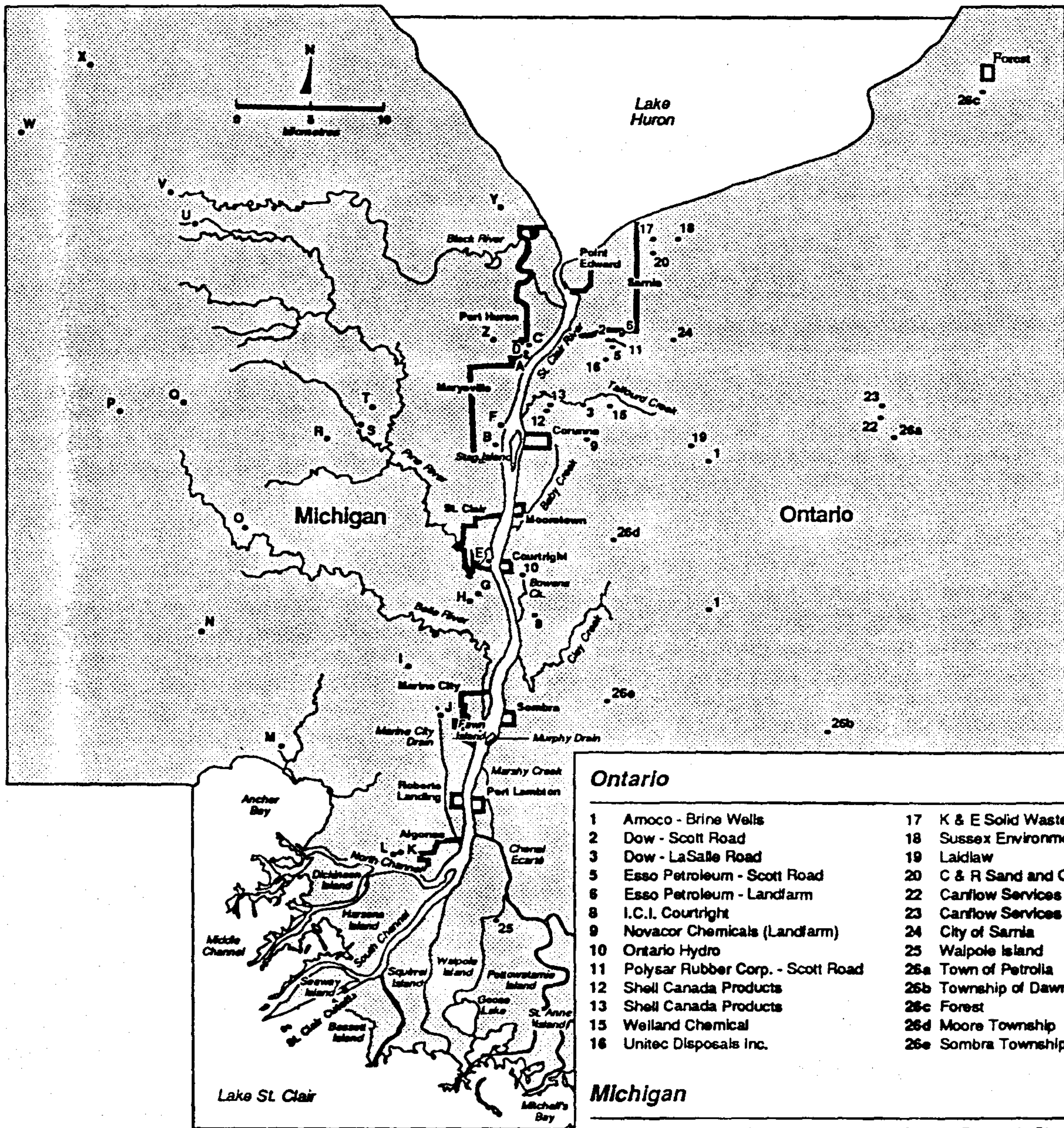
Industrial Disposal and Landfill Sites	Actively Accepting Waste in 1990
1. Amoco - brine disposal well	Yes
2. Dow - Scott Road, chlorinated hydrocarbons	No
3. Dow - LaSalle Road -non-hazardous waste	Yes
-registered waste	Yes
4. Dupont - spent aluminum catalyst	No
5. Esso Petroleum - Scott Road landfill	Yes
6. Esso Petroleum - Landfarm, Lime sludge	Yes
7. Fiberglas	No
8. I.C.I. Courtright - gypsum and radioactive waste	No
9. Novacor Chemicals - Corunna, landfarm	Yes
10. Ontario Hydro- Courtright, flyash and trash	Yes
11. Polysar Rubber Corp.- Scott Road, landfill	Yes
12. Shell Canada Products - landfarms	Yes
lead sludge disposal sites	No
13. Shell Canada Products - lime disposal	No
14. Suncor - landfarm	Yes
15. Welland Chemical	No
16. Unitec Disposals Inc. - Moore Township	Yes
17. K & E Solid Waste Management - Sarnia Township	Yes
18. Sussex Environmental Services Inc. - const. debris	Yes
19. Laidlaw (formerly Tricil)	Yes
20. C & R Sand and Gravel	Yes
21. Ladney - Moore Township	No
Waste Disposal Sites of Concern	
22. Canflow Services (formerly P & E Recylers)	Yes
23. Canflow Services - Petrolia	Yes
Municipal Waste Sites Near St. Clair River	
24. City of Sarnia (operation assumed by County of Lambton - Landfill	Yes
25. Walpole Island - Landfill	No
26. County of Lambton Municipal Landfills	
a) Town of Petrolia	Yes
b) Township of Dawn	Yes
c) Forest	No
d) Moore Township	Yes
e) Sombra Township	Yes
f) Brooke Township	Yes
g) Grand Bend	Yes
h) Laidlaw (Warwick Twp. Privately Owned)	Yes

Figure 8.4

St. Clair River Remedial Action Plan

Location of waste disposal sites and landfills

(sites identification keyed to text)



Ontario

- 1 Amoco - Brine Wells
- 2 Dow - Scott Road
- 3 Dow - LaSalle Road
- 5 Esso Petroleum - Scott Road
- 6 Esso Petroleum - Landfarm
- 8 I.C.I. Courtright
- 9 Novacor Chemicals (Landfarm)
- 10 Ontario Hydro
- 11 Polysar Rubber Corp. - Scott Road
- 12 Shell Canada Products
- 13 Shell Canada Products
- 15 Welland Chemical
- 16 Unitec Disposals Inc.
- 17 K & E Solid Waste Management
- 18 Sussex Environmental Services
- 19 Laidlaw
- 20 C & R Sand and Gravel
- 22 Canflow Services
- 23 Canflow Services - Petrolia
- 24 City of Sarnia
- 25 Walpole Island
- 26a Town of Petrolia
- 26b Township of Dawn
- 26c Forest
- 26d Moore Township
- 26e Sombra Township

Michigan

- A Hoover Chemical/Reeves Product Waste Disposal Site
- B Willis Street Dump
- C Winchester Disposal Site
- D A & B Waste Disposal Site
- E John A. Biewer Company Inc.
- F River Road Contamination Site
- G Belle River Berm Project
- H Range Road Property
- I Huron Development
- J Norman Markel LF
- K Clay Township SLF
- L City of Algonac SLF
- M Ira Township Disposal
- N County Line Landfill
- O Richmond Hills LF
- P City of Memphis SLF
- Q Wales Township Disposal
- R Vlasic Foods Inc. SLF
- S Smiths Creek LF
- T Blue Water Constr. LF
- U Sanitary Landfill Area #2
- V Angus Cameron Dump
- W Lynn Township Dump
- X Yale Sanitary Landfill
- Y Fort Gratiot SLF/Howards Disposal
- Z Green Salvage Co.

It should also be noted that a number of operators are seeking increases in loading rates and the permitted waste disposal area for their sites. For example, the Ontario Hydro Lambton Generating Station will require increased capacity to handle sludge from scrubbers once the scrubbers are installed.

8.3.1.2.1 Ontario Industrial Waste Sites and Landfills

1. AMOCO Canada Petroleum Co. Ltd., Brine Disposal Wells

AMOCO Canada Petroleum Company Ltd. owns and operates two brine disposal wells both of which were formerly owned and operated by Cambrian Disposal Ltd.

Waste disposal site known as CDL #1 is a deep disposal well operated under CofA number A032001. The site is located on Lot 7 Concession 1, Sarnia Township. The site has been operating since 1971. A total of 7,597,299 m^3 (1,975.2 X 10^6 U.S. gal) of wash brine has been injected as of January 1, 1990. A total of 121,728.59 m^3 (31.6 X 10^6 U.S. gal) of brine was injected in 1989. All water wells, within a 1 mile radius of the disposal site plus wells adjacent to the site on Lot 10 Concession 1, Sarnia-Clearwater and Lot 4 Concession 12, Moore Township, are monitored quarterly for evidence of contamination.

AMOCO's second deep disposal well is known as CDL #6 and is operating under CofA number A031807. It is located on Lot 3 Concession 9, Township of Moore and is used to dispose of cavern washing brine from the Sarnia petrochemical industry. The wastes have been injected into bedrock of the Detroit River Group since 1974 with a total of approximately 1,295,000 m^3 (336.7 X 10^6 U.S. gal) being injected as of 1985. Wells on neighbouring lots are monitored quarterly for evidence of contamination.

2. Dow, Scott Road Site

The Dow Chemical Canada Inc. waste disposal site off Scott Road in Sarnia (part Lots 10 and 11 Range 3, RP 122 Scott Road) served the nearby Dow manufacturing facilities. The site commenced operation in 1948 but has been inactive since January 1987. Disposal operations consisted of controlled landfilling and clay capping of hazardous and non-hazardous solid and liquid wastes that originated from a number of plants including the vinyl chloride plant. Included are various oily sludge and solvents containing chlorinated hydrocarbons, specifically hexachlorobutadiene. Contaminated soils and equipment from around the production facilities were disposed at the site. Approximately 1,000 tonnes (1,102 tons) of waste (28% non-hazardous, 26% liquid and 46% hazardous waste) were received annually (OMOE 1990b).

The site, approximately 4 ha (10 acres) in area, is situated on a thick clay till deposit extending more than 30 m (100 ft) to the underlying bedrock of Kettle Point shale. The leachate control system consists of a drainage tile around the perimeter of the site and an underground holding tank. The collection/holding ditch, while it may gather some leachate, is primarily intended for the collection of surface runoff. The contents of the ditch are treated via activated carbon beds then released to the Scott Road Ditch which drains to the Cole Drain. In addition, a steel sheet pile wall has been installed around the full perimeter of the site to a depth of 4 to 5 m (13 to 16 ft) below grade to control any off-site leachate migration. However, the effectiveness of the sheet pile wall to contain off-site groundwater flow has not been demonstrated.

The adequacy of the existing leachate collection system to prevent off-site migration of contamination from this site has not been proven. Groundwater mounding within the landfill could create a large hydraulic gradient across the sheet pile wall thus resulting in some leachate passing through the wall and increased off-site groundwater flow.

Dow found that the Cole Drain sediments were highly contaminated by tars discharging from the site prior to 1980. In 1984, the entire Cole Drain from Scott Road to Polysar (where the drain is replaced by a concrete-lined channel) was dredged and the contaminated material was disposed at the Scott Road landfill.

3. Dow, LaSalle Road Site

Dow Chemical Canada Inc. operates an industrial waste disposal site near LaSalle Road in Moore Township under CofA numbers A031801 and A031802. The site is approximately 40 ha (100 acres) in size and currently accepts 26,000 tonnes (28,652 tons) of solid waste and 500 m^3 (655 yd^3) of filter cake sludge per year. The wastes include latex solids, polyglycol filter cake, BIOX filter cake, and nonhazardous solid industrial waste. The waste is characterized as 99 percent non-hazardous and 1 percent liquid industrial waste. The operation consists of controlled landfilling with clay capping. Berms, perimeter ditches and two surface water runoff collection ponds are included on the site. A hydrogeologic study was conducted by Dominion Soil Investigation in 1983. Five borehole/piezometers were installed to a maximum depth of 10 m (33 ft). Local groundwater flow was determined to be northward towards Talfourd Creek at less than one cm/year (< 0.39 in/year). The local surficial soils were determined to be a low plasticity silty clay which are relatively uniform in nature. The top 6 m (20 ft) were fractured. Till permeabilities of the order of 10^{-7} cm/sec (0.39 X 10^{-7} in/sec) with variations of approximately one order of magnitude for the clay with or without fractures were established.

The most likely pathway for leachate migration movement off-site would be via surface runoff and shallow groundwater flow. Problems with surface runoff of lime sludge to adjacent CN property have occurred in the past. Construction of perimeter ditches and a surface water containment pond has reduced the potential of off-site contaminant migration via surface runoff.

4. DuPont, Corunna

DuPont's spent aluminum catalyst waste site is no longer used for disposal.

5. Esso Petroleum Scott Road Landfill Site, Sarnia

Esso Petroleum Canada operates a landfill for non-hazardous refinery wastes and construction debris near Scott Road in Sarnia. The site is located in Range 3 Lots 8 and 9 of Lambton County. The Esso landfill is registered under CofA number A030105 and in 1985 received about 4,000 tonnes (4,408 tons) of non-hazardous refinery coke and spent catalysts and 57,000 tonnes (62,814 tons) of construction and demolition debris.

The site is situated on the regional clay-till plain. Hydrogeologic investigations available for the nearby Polysar Limited landfill area suggest that the tills have hydraulic conductivities in the order of 10^{-8} cm/sec (0.39 X 10-8 in/sec). It is likely that the shallow groundwater movement on-site is radially outwards from the site at very limited rates. A berm has been constructed on the southwest corner of the site and drainage is generally to the east of the Cole Drain. Both groundwater and surface water monitoring are currently ongoing at the site.

6. Esso Petroleum Canada, Waste Disposal Site, Sarnia

Esso Petroleum Canada Ltd. currently disposes of approximately 17,900 m^3/year (23,449 yd^3) of their Sarnia refinery wastes through landfarming on an eight hectare (20 acre) area in Range 2 Lots 10 and 11 in Lambton County. The wastes consist of lime sludge, aerobically digested activated sludge and oil sludge. The site is located approximately 5 km (3.1 mi) from the St. Clair River on a poorly drained portion of the regional till plain. The site is operated under CofA number A032013 (Certificate no. changes to A30112). The tills are regionally known to limit infiltration and shallow groundwater movement. Site specific geology or hydrogeology studies are not available. Surface water and leachate from underdrain collector tiles are directed to the refinery's BIOX plant. Shallow groundwater is monitored by in-place wells and sampled by the company.

7. Fiberglas Canada Inc. Scott Road Landfill Site, Sarnia

Fiberglas Canada's former landfill site is situated off Scott Road adjacent to Dow's and Polysar Rubber Corporation's landfill sites. This site is no longer accepting wastes. A Scott Road watershed survey (Conestoga Rovers and Associates 1989) found that dichloromethane and chloroform inputs to the Cole Drain occurred in the section of the drain fronting the Fiberglas and Dow disposal sites, as well as the Polysar Rubber Corp. Flyash pond.

8. ICI Nitrogen Products Waste Disposal Site, Courtright

The ICI Nitrogen Products plant near Courtright produces chemical fertilizers. The plant site is located approximately 1 km (0.6 mi) east of the St. Clair River in Lots 3 and 4 Concession 15 of the Municipality of Sombra. There is little topographic relief but surface drainage is either directed towards the river or eastward into Clay Creek.

Present operations and waste storage facilities were originally approved by the Ontario Water Resources Commission in 1966. The fertilizer manufacture included the use of phosphate rock which naturally contains minor amounts of radioactive radium and uranium. These elements eventually appeared in a waste gypsum slurry which was discharged into two 50 ha (123.5 acres) holding ponds. The phosphates plant was closed in 1986, thus ending the discharge of the waste gypsum slurry to the pond system. The ponds also contain phosphate, ammonia and fluoride with a water pH of 1.0. Drainage ditches around the perimeter of the ponds collect any pond seepage. Surface water and groundwater monitoring is conducted.

In the period 1975 to 1981, separation filters containing radium concentrations as high as 12,000 pCi/g from the ICI manufacturing process were disposed at the Sombra Township (Wilkesport) Landfill Site. This disposal resulted in areas with a high radiation exposure rate and localized hot spots. Under direction of OMOE and the Ontario Ministry of Labour, ICI removed two truckloads of contaminated soil from the landfill for storage at the edge of one of ICI's gypsum ponds. The contaminated soil was then accidently pushed into the pond. Another radiation survey of the landfill identified two areas of elevated exposure rate and a further four truckloads of contaminated soil was removed to the ICI location.

As a result, a CofA, Number A032105, was given to ICI to cover the once-only disposal of the low level radioactive waste, contaminated soil and debris collected from the Sombra Township Landfill. The wastes are presently contained inside the walls of the gypsum pond. All radioactive materials (i.e. separation filters) are now stored in a concrete bunker on-site.

9. Novacor Chemicals Landfarm Waste Site, Corunna

This company commenced operation of a landfarm in 1986 on a 6.6 ha (16.3 acres) site at the Corunna facility. Approximately 3.9 ha (9.6 acres) of the site is utilized for land-spreading. The site receives a maximum of 51,300 L/ha/yr (5,400 U.S.gal/acre/yr) of oil contained within liquid industrial wastes. The waste is contaminated with light and heavy fuels, waste oil petroleum-based sludges, oily water and biological sludges.

Surface runoff and under-drainage from the spreading area are collected and placed in a holding pond. If the effluent attains OMOE Effluent Quality Guidelines (CofA), it is discharged to the Allingham Drain. If it does not meet the guidelines, then the effluent is discharged to the oily water treatment facility located on-site.

10. Ontario Hydro Landfill, Courtright

Ontario Hydro's Lambton Thermal Generating Station is a coal-fired plant located near the town of Courtright. The plant produces about 280,000 tonnes (308,560 tons) of coal ash and 2,800 tonnes (3,086 tons) of trash annually, mainly weeds from river water intake, which is locally landfilled on-site. The landfill is currently active and registered under CofA number A031802.

The plant site extends eastward 1.5 km (0.9 mi) from the St. Clair River with the western edge of the 43 ha (106.2 acres) landfill located about 0.6 km (0.4 mi) from the river. Topographic relief on-site is minimal, but locally directs surficial drainage towards the river or into Bowens Creek which discharges into the river approximately 2 km (1.2 mi) south of the plant.

The site is underlain by over 40 m (131 ft) of silty clay till which typically ranges from 50 to 60 percent clay. Detailed on-site studies at two locations indicate that the hydraulic conductivity of the till is very low, ranging from 0.5 to 15 X 10^{-8} cm/sec (0.195 to 5.85 X 10^{-8} in/sec) (OMOE 1990b). Overall horizontal movement of shallow groundwaters is directed towards the river at rates from cm/yr to m/yr, depending upon the extent and characterization of weathering of the tills. Rates of downward movement are in the order of cm/year.

Bottom ash from the plant is initially slurried into a settling pond but is regularly transferred to the main flyash landfill. The landfill is an above-ground operation. Drainage pathways around the landfill collect runoff into a pond for pH adjustment and monitoring. The pond is decanted to the St. Clair River. General plant site drainage is controlled by perimeter ditches. Groundwater monitoring is conducted.

11. Polysar Rubber Corporation Scott Road Waste Disposal Site, Sarnia

The Polysar Rubber Corp. disposal site off Scott Road in Sarnia is currently active and serves the nearby Polysar manufacturing facilities. The site has been in operation since 1942 and consists of industrial waste and flyash areas. Disposal operations consist of the controlled landfilling of various inert sludge, plastic resins (no current additions, historical only) and alkali, inorganic and rubber wastes over an area of approximately 11 ha (27 acres). At present, approximately 25,000 m^3 (6.5 X 10^6 U.S. gal) of liquid wastes are received per year. Landfilling is accompanied by capping of wastes with imported clay and silty clay material. Surface runoff and waste leachates are directed into surface storage lagoons where monitoring and treatment are required. Monitored parameters include pH, total organic carbon, phenols, copper, and ammonia. Off-site release of surface waters has ceased, and all surface waters are now treated at the company's BIOX treatment plant.

Shallow preliminary hydrogeologic investigations were completed on-site by Dominion Soil Investigations Inc. in 1984. Borehole logging and piezometer installation were completed. Five piezometer nests of two piezometers each were located and installed at the corners and centre of the site. The studies indicate that several metres of fill wastes overlie more than 10 m (33 ft) of silty clay till. On-site, however, portions of the landfill apparently rise more than 8 m (26 ft) above the ground. Hydraulic conductivities in the tills vary from 8 X 10^{-8} cm/sec (2.9 X 10^{-8} in/sec) to 3 X 10^{-7} cm/sec (1.2 X 10^{-7} in/sec) and greatly restrict groundwater movement. Using the measured water table gradient of 0.01:1 and an assumed porosity of 0.1 in the weathered surficial till, the shallow groundwater movement on-site is in the order of 10 cm/year (3.9 in/year). Shallow lateral movement is apparently directed outward from the landfill and may eventually discharge into perimeter ditches or be lost through evaporation. Data also suggest that vertical groundwater movement on-site is downward. Downward movement towards a deep aquifer at the bedrock surface is consistent with the general regional hydrogeology.

Groundwater quality monitoring was subsequently conducted in the set of deeper piezometers installed from 9.6 to 14.2 m (31.5 to 46.6 ft) below ground. The groundwater quality in two piezometers, one located to the northeast of the landfill an another to the northwest but adjacent to one of the lagoons, had elevated dissolved organic carbon and phenol concentrations. These results should be confirmed by further analysis. The groundwater quality along the down-gradient perimeter on the site (tens of metres beyond the landfill or lagoons) showed no evidence of possible quality changes due to the operation of the landfill.

Leachate springs have been noted by OMOE officials on the east berm surrounding the industrial waste landfill and containment of surface runoff on the east side of the landfill is considered inadequate.

In 1989, Conestoga Rovers and Associates carried out a study of surface runoff within the Scott Road watershed in order to determine the origin of contaminants in the Cole Drain. The primary contaminants found within the Scott Road Drain and connecting Polysar perimeter drain were found to be tetrachloroethylene (from sediments or an unidentified tile drain); dichloromethane and chloroform (inputs occurred in the section of drain fronting the Fiberglas and Dow disposal sites as well as the Polysar Flyash Pond); and 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane and 1,2-dichloroethane (seepage from the embankment of the Polysar Flyash Pond along with seepage directly to the perimeter ditch). The authors concluded that the Sarnia Sludge Lagoon and the Esso Petroleum Tank Farm were not likely sources of priority pollutants. One site was identified as potentially contaminating runoff and shallow groundwater.

12. Shell Canada Lime Disposal Ponds

Shell Canada Limited operates an oil refinery along the banks of the St. Clair River 12 km (7.4 km) south of Sarnia. The refinery has been in operation since the 1950s and operates several waste sites. The lime disposal area, operated under CofA number A031817, was a 0.25 ha (0.62 acres) settling pond used to contain spent lime from treated process waters. The CofA was revoked in 1986 and the site was covered.

The plant site is underlain by the clay till plain present throughout the Sarnia area. Surficial drainage is locally directed towards Talfourd Creek which passes along the northwestern edge of the site. The hydraulic conductivity of the shallow tills varies from 1×10^{-10} m/sec (3.28×10^{-10} ft/sec) to 1×10^{-8} m/s (3.28×10^{-8} ft/sec) and horizontal groundwater movement within them is predicted to be northwestwards toward Talfourd Creek at a rate of 10 cm/year (3.9 in/year).

Surface and groundwater monitoring is not carried-out in the lagoon area. The most likely pathway for leachate movement off-site would be seepage through the dike and surface runoff towards Talfourd Creek. Shallow groundwater flow is directed towards Talfourd Creek.

13. Shell Canada Landfarm Site

Shell Canada Limited operates several waste sites within the plant site. The "north field" site is a 4.1 ha (10.1 acre) area, of which 2.8 ha (6.9 acres) is currently used for the landfarming of 680 m^3/year (890 yd^3/yr) of biosludge and oil wastes. It is operated under CofA number A031819. Associated with the land farming is a sludge holding lagoon. A geologic and hydrogeologic survey indicated that a thick clay and silt unit underlies the north field site and that groundwater flow occurs in a northwesterly direction towards Talfourd Creek. The hydraulic conductivity varies from 1×10^{-10} m/sec (3.28×10^{-10} ft/sec) to 1×10^{-8} m/sec (3.28×10^{-8} ft/sec) and when combined with low horizontal hydraulic gradients across the site, resulting groundwater movement has a rate of 10 cm/year (3.9 in/year).

Studies undertaken in 1982 by McLaren Plansearch suggest that the landfarming has had no apparent effect on general water quality parameters such as pH, conductivity, chloride, ammonia, nitrate, phenol, oil and grease and dissolved organic carbon. Accordingly, there is no reason to suspect trace element migration (OMOE 1990b).

Local runoff collection is provided around the landfarming area and directed into the stormwater collection system. This is treated with process water. Drainage has also been enhanced by the installation of a tile drainage system in 1983. This site appears to have a low potential for affecting the quality of the St. Clair River water (OMOE, 1990b). Current groundwater and surface water monitoring appears to be adequate.

The north field landfarm waste disposal site is currently active. Shell Canada has a dormant "south field" biosludge disposal area, 2.7 ha (6.7 acres) in size of which 2.4 ha (5.9 acres) can be spread with biosludge. This field is currently being upgraded for use in 1991.

Associated with the refinery operation are three former disposal areas: a leaded sludge disposal site, located northwest of the sludge holding lagoon; a small lead disposal, located adjacent to Talfourd Creek; and a leaded-sludge disposal area near the north field landfarm. These areas consist of lead-contaminated sludges buried near some of the gasoline storage tanks. The leaded-sludge disposal area was covered under CofA number A031809. This certificate is no longer in effect. The disposed sludge was not excavated prior to closing the sites. The leaded-sludge disposal area is adequately covered by the monitoring wells installed between the disposal area and the creek. The small lead disposal area near Talfourd Creek does not have monitoring wells and residual contamination could migrate short distances to the creek.

14. Suncor Inc. Landfarm Wastes Disposal Site, Sarnia

Suncor Inc. currently utilizes a landfarm waste disposal site on the refinery premises. It operates under CofA A030113 for the landfarming of oil and water, shop oil, tank sludge, oily sand and water, skimmer sludge, oily sludge, and BIOX sludge. The site has six wells to monitor groundwater quality.

15. Welland Chemicals Ltd. Landfill and Waste Disposal Site, Sarnia

Welland Chemicals (formerly St. Clair Chemical Company) is located on Scott Road, within the Sarnia Indian Reserve, a few kilometres from the city limits of Sarnia. A dormant landfill, drum storage and liquid effluent storage ponds are located on the property. All liquid wastes from the anhydrous aluminum chloride plant and chlorine repackaging plant pass through a lagoon system prior to discharge to the Scott Road ditch which drains into Talfourd Creek.

In 1974 and 1975, Welland Chemicals disposed of an unknown quantity of anhydrous aluminum chloride which did not meet their purity specifications for marketing. This material was buried on-site, possibly in 45 gallon (200 L) steel drums. The quantity, exact location and depth of this waste are not specifically known. The presumed site of the landfill has been covered and graded, but not revegetated.

Local geology consists of 3 to 5 m (10 to 16 ft) of brown weathered clay till overlying in excess of 30 m (100 ft) of grey till overlying Kettle Point Shale bedrock. Groundwater flow, permeability and surface and groundwater quality analyses were done by Proctor and Redfern Group with Gartner Lee Associates Limited in 1981 and O.H. Materials Co. in 1984.

Surface runoff at the site was collected in perimeter ditches that empty into Talfourd Creek. Water samples from these ditches were the first indication of leachate migration. Recent clean-up of surface on-site storage locations, construction of a subsurface drainage collection system for surface water and two on-site surface water treatment ponds have improved the quality of water discharged from the plant property. Groundwater samples collected from on-site monitoring wells indicate an improvement in water quality since 1981.

16. Unitec Disposals Inc. Waste Disposal Site, (formerly Holmes Insulation)

The Unitec Disposals Inc. waste disposal site located off Scott Road on the west half of Lot 22, Concession 12, Township of Moore. The total area of the site is 37.2 ha (91.9 acres) of which 32.4 ha (80 acres) are licensed for landfilling (CofA number A031810). The site has been in operation since 1974 and currently is approved for the disposal of non-hazardous solid industrial waste comprised of insulation materials, including asbestos, plastics, rubber, catalyst and packaging material. The site serves industry within Lambton County and may accept up to 18,250 tonnes (20,112 tons) of waste per year.

In addition to the landfilling operation, Unitec operates a spray irrigation system on-site for liquid industrial wastes (CofA number 4-0082-89-006) limited to landfill leachate and process wastewaters from Fiberglas Canada Inc. in Sarnia. Surface runoff and waste leachate from on-site are collected within individual cells which drain to a collection well and are pumped to a storage lagoon for use in the spray irrigation system. In addition, waste leachate is received from the closed Fiberglas Landfill on Scott Road. Groundwater samples are collected on a monthly basis from two on-site monitoring stations and results, volumes received and sprayed area reported to OMOE in Sarnia. The total volume allowed to be sprayed is 38,500 m^3/year (10×10^6 U.S. gal/year) (May through October).

Local geology indicates that approximately 4 m (13 ft) of brown oxidized clay till overlies in excess of 30 m (100 ft) of grey clay till which overlies Kettle Point Shale bedrock.

Unitec has made application for expansion on both the landfilling and spray irrigation operations and is currently completing a submission under the *Environmental Assessment Act*. In support of this application, detailed hydrological investigations, including surface and groundwater monitoring have been conducted since the fall of 1986. Surface runoff from the spray irrigation area will be the most likely pathway for leachate movement off-site.

17. K & E Solid Waste Management Site

The K & E Solid Waste Management site is owned by A. Philip Environmental Company of Hamilton, Ontario. It is located in Sarnia-Clearwater, part Lots 47 to 51, Front Concession. The total area of the site is 44.5 ha (110 acres) of which 32.4 ha (80 acres) are licensed for disposal under CofA number A032006. The site serves southwestern Ontario and is approved to accept a total of 31,200 tonnes (34,382 tons) per year of non-hazardous solid waste and non-putrescible domestic waste.

The site is located in glaciolacustrine sand and gravel that overlies clay till. The total depth of overburden is approximately 30 m (100 ft) and this overlies the Kettle Point shales. A preliminary hydrogeological assessment of the K & E site was conducted in 1983 by OMOE in order to assess whether the disposal of waste has had an impact on the hydrogeologic environment and surface water. Results of surface water sampling of several on-site ponds revealed an increase above background of several constituents, namely specific conductance, chloride, sodium, organic nitrogen, iron, biological oxygen demand and chemical oxygen demand caused by the disposal of wastes. In this study, an assessment of the impact of the surface water drainage on the receiving storm sewer water was prevented because of the lack of a suitable background water quality sample.

Results from a detailed groundwater, surface water, leachate and gas monitoring program are currently under review by OMOE. At present, gas monitoring and surface water sampling at discharges are conducted on a regular basis. The most likely pathway for leachate movement would be by subsurface seepage in the sand and gravel towards Lake Huron to the north. Surface runoff is pumped to a main sewer trunk which flows to a roadside ditch (Michigan Avenue) which drains via Wawanosh Drain to Lake Huron. The Certificate of Approval for this site has been updated and the company is preparing a design and operations plan.

18. Sussex Environmental Services Inc. Waste Disposal Site, (formerly Ed Johnson Construction Company Ltd.)

Sussex Environmental Services Inc. operate an 8.1 ha (20 acre) waste disposal site off Blackwell Road in Sarnia-Clearwater northern sections of Lots 42 and 43 Concession 9 (CofA number A032014). In 1989, the site received 32,190 m^3 (42,169 yd^3) of construction and demolition debris.

The site itself is an abandoned sand pit that is kept dewatered by constant pumping at a rate of 9.1 X 10-3 m^3/s (2,366 X 10^{-3} U.S. gal/s). Locally, up to 10 m (33 ft) of fine sand overlies approximately 30 m (100 ft) of silty clay till, which overlies Kettle Point shale. The sands appear to be continuous from the site to Lake Huron. A hydrogeologic investigation was carried out by Conestoga Rovers and Associates in 1979, prior to the disposal of waste at the site. Piezometers were installed, soil and ponded pit water samples were taken in order to characterize the site. The sand pit is fed from the local perched unconfined aquifer. Since 1988, Conestoga Rovers and Associates have been conducting routine surface and groundwater sampling. The water from this aquifer is used locally for irrigation purposes only and not domestic use.

Leachate seepage is being monitored at this waste disposal site. It is anticipated that any leachate movement off-site will be via subsurface seepage.

19. Laidlaw Environmental Services (Sarnia) Ltd. Industrial Waste Disposal Site, (formerly Tricil Ltd.)

The Laidlaw Environmental Services (Sarnia) Ltd. waste disposal site is located in Lot 9, Concession 10 in the Township of Moore about 12 km (7.4 mi) southeast of Sarnia. The site has been in operation since 1962 and currently operates under CofA numbers A031806, A031813 and A031822. In 1989, 161,755 m^3 (211,900 yd^3) of solid waste were received at the site for landfilling. A further 16,131 m^3 (4.2 X 10^6 U.S. gal) of non-solid wastes were received at the landfill pretreatment system (A031822) and then landfilled. In 1989, 45,000 m^3 (11.7 X 10^6 U.S. gal) of liquid waste were incinerated in the Liquid Injection Incinerator (A031813) at the site. Liquids are generally incinerated on-site but if unsuitable, are mixed with fly ash and placed in a controlled solid waste landfill. Waste treatment and disposal operations occupy approximately 26 ha (64.2 acres). Site expansion was approved in 1986.

The site is underlain by over 40 m (131 ft) of silty clay till of relatively low hydraulic conductivity. A regional 'freshwater aquifer' exists beneath the till at the bedrock surface. An extensive three-dimensional groundwater monitoring network is in place on-site within the till and underlying aquifer.

The hydraulic conductivity of the tills from field and laboratory measurements was found to be less than 10^{-10} m/sec (3.28 X 10^{-10} ft/sec) and downward groundwater movement was estimated to be less than 1 cm/year (0.39 in/year) (Hydrology Consultants Limited, 1984). Shallow radial groundwater movement from the site is possible through the upper weathered portion of the till but current monitoring demonstrates that this movement is very limited.

It is estimated that groundwater movement from surface to the deep aquifer would take 40,000 years or more. Migration of contaminants by chemical diffusion, however, could take considerably less time. Groundwater movement within the aquifer is locally towards the northeast, away from the St. Clair River.

There is little topographic relief on-site and natural surficial drainage may enter either the Thorton Drain or Talfourd, Perch or Bear Creeks. However, local drainage around the treatment and disposal areas is controlled and drainage returned to the plant for incineration or biological and activated carbon adsorption treatment with discharge to a local drain. Current surface and groundwater monitoring has been upgraded upon expansion of the site.

20. C & R Sand and Gravel Ltd. Landfill Site

C & R Sand and Gravel Ltd. operates a 6 hectare (15 acre) landfill site in Sarnia-Clearwater, west half of Lot 17, Concession 8 under CofA number A032005. The site has been receiving non-hazardous solid waste consisting of logs, brush, construction rubble, and earth fill since 1971, in amounts averaging 200 tonnes (220 tons) per year (application was for 3,120 tonnes/3,438 tons per year). Presently, due to the non-hazardous nature of the waste material, no systems for containment or control of surface runoff or leachate seepage have been implemented. Also, there are no monitoring systems. The site is currently active.

The site is an abandoned gravel pit that overlies clay till to Kettle Point shale bedrock at a depth of more than 30 m (100 ft). Hydrogeological data have not been collected for the site, nor has any water geochemistry characterization been conducted. The most likely pathway for leachate movement off-site would be by subsurface seepage.

21. Ladney Waste Disposal Site, Moore Township

This property was used as an industrial waste disposal site by A.P. Goodfellow during the late 1950s and early 1960s. The site received a wide variety of industrial wastes both as bulk waste, and in drums. Wastes were buried on-site. Following termination of the disposal operations, several areas of exposed tar and open pits remained. During the early 1970s the owner was taking some action to cover the exposed tar and fill-in the pits.

The property was sold in 1974, however, the closure work was not satisfactory. In 1980 OMOE issued a Control Order to the new owner requiring a suitable cover be applied in the areas of exposed tar and open pits to prevent contamination of surface runoff. This order was complied with and the work appears to have resolved the concerns. However, the possibility of groundwater contamination or subsurface seepage to nearby drainage ditches has not been assessed.

22. Canflow Services (formerly P & E Oil Recyclers) Waste Disposal Site, Petrolia

The Canflow Services (formerly P & E Oil Recyclers) site is situated on part of Lot 12, Concession 12 in the Township of Enniskillen and serves all of Ontario. The site has existed since the late 1800s and has been licensed since 1971 under CofA number A031602. The site is currently active.

The site is located in a clay till overlying the Hamilton Formation shales and limestones. The approximate thickness of the overburden is 30 m (100 ft). No surface water or groundwater monitoring programs are in place.

The site was developed in the latter part of the nineteenth century by the Canadian Oil Company for the subsurface storage of crude oil in underground wood-lined tanks. The tanks were excavated in heavy clay soil to depths ranging from 4 to 18 m (13 to 59 ft) below grade.

In 1965 and 1969, two deep disposal wells were drilled into the Detroit River group and were used for the disposal of liquid industrial wastes until 1984 when OMOE regulated against the disposal of industrial wastes in this fashion, except for oil field brine. This regulation led to the storage of industrial wastes in the aforementioned subsurface storage tanks. Oil field brines continue to be injected into one of the deep wells under authority of the Ministry of Natural Resources. The other well has been plugged. This is a separate operation unrelated to the OMOE CofA.

In 1979, as re-refined used oil became increasingly marketable, the site owner expanded into the oil recycling and reclamation business. This led to OMOE approval for an on-site oil recovery unit and the on-site disposal of oil reclamation solids. The site has been operated by Canflow since 1982 and is approved to process liquid industrial and liquid hazardous wastes (only fuel and oily wastes). Processing is limited to physical separation and the site accepts up to 29,780 m^3 (7,742,800 U.S. gal) of liquid waste per year. The main purpose of the site remains oil reclamation and recycling. All storage tanks used in the operation are above-ground steel tanks with berms around the industrial storage areas to provide contaminant and surface water control. In addition, a berm has been constructed around the site perimeter in order to control surface runoff.

The underground storage tanks have a capacity of over 13,650 m^3 (3,549,000 U.S gal) and the last documented OMOE report indicates that all are full. The liquid contents of the tanks were sampled and analyzed by OMOE in November 1983. The results indicate that the tanks contain oil, brine, water, caustic and/or acidic compounds, phenolic compounds, mineral salts and heavy metals including lead and chromium.

Many of the inground tanks remaining on the site are uncovered, or those that are covered, have weak and rotten wooden covers, therefore allowing infiltration of precipitation which potentially can cause overflows of the contents. Tank contents are periodically pumped down and disposed of off-site to prevent potential surface water contamination. A 1988 OMOE engineering survey located all existing inground tanks. A chemical analysis of the contents was done and a hydrogeologic study carried out. The survey concluded that there was no evidence of groundwater contamination and presented proposals to suitably treat the stored wastes.

23. Canflow Services Waste Disposal Site

The Canflow Services (formerly 559741 Ontario Inc.) waste processing and disposal site is located on part of Lot 13, Concession 12 in the Town of Petrolia. This is the site of the former Canadian Oil refinery which manufactured heavy lubricating oils on-site at the turn of the century. Large quantities of oleum (strong sulphuric acid) were used in the treatment stage and after use, the spent acids were stored in below-grade wood-lined storage tanks. Approximately 4,460,000 L (1,159,600 U.S. gal) currently remain on-site.

The site has been operated by Canflow since 1983 under CofA number A030330 and is approved to store and process liquid industrial and liquid hazardous wastes limited to alkalis, fuels and oily wastes. Processing is limited to neutralization of refinery acids stored on-site and to physical separation. The site may accept up to 600 m^3 (156,000 U.S gal) of waste per year. In addition, Canflow accepts up to 2 tonnes/day (2.2 tons/day) of non-hazardous solid waste, restricted to spent lime and construction and demolition debris for the purpose of backfilling inground storage tanks once emptied.

The site is situated in a clay till plain with the surficial deposits being glaciolacustrine clays overlying the clay till. Depth to bedrock is approximately 30 m (100 ft). The most likely pathway for leachate movement off-site would be by surface flow. Currently no systems for the containment or control of leachate are in place. A berm has been constructed around the site to control surface runoff. No shallow groundwater monitoring is being done at present.

8.3.1.2.2 Ontario Municipal Waste Sites

On January 1, 1991, under the *Sarnia-Lambton Act*, 1989, the County of Lambton assumed responsibility for waste management from the area municipalities. There are eight landfills in Lambton County licensed to accept residential and commercial (municipal) solid wastes. Six of the sites were owned by area municipalities and have been transferred to the County. Two sites (Warwick and Petrolia) are owned by private companies. Of the six county owned sites, the Grand Bend and Sombra sites are close to being full and the County plans to establish closure plans.

Lambton County plans to carry out site hydrology surveys to determine if any problems exist. Closure plans will be developed for all sites together with plans for leachate control in order to protect surface and groundwater.

24. City of Sarnia Landfill

The City of Sarnia operates a landfill within the Township of Sarnia on the north half of Lot 12 Concession 3 under CofA number A032002. The disposal operations occur on a 30 ha (74 acre) parcel within the 40.5 ha (100 acre) site. At present, approximately 52,000 tonnes/year (57,304 tons/year) of refuse are disposed from the City of Sarnia, Township of Sarnia and the Village of Point Edward. The waste is comprised of predominantly domestic waste with some commercial (18%) and bulk waste (appliances, furniture, leaves, brush, 27%).

The site is located on 40 m (131 ft) of clay till overlying the Hamilton Formation shales and limestones. Prior to 1985, this landfill was poorly managed and presented several problems, such as, leachate springs, inadequate drainage, ponded water and poor cover material. Although there are no reported impacts on groundwater, there is potential for surface water to be adversely affected by runoff. In 1985, the City of Sarnia carried out improvements to the site, including the installation of a containment berm and leachate collection system along the east side, together with drainage ditches and a sedimentation pond. The City has installed leachate collection and treatment facilities which commenced operation in July, 1990.

25. Walpole Island Indian Reserve Landfill

A small (0.3 ha, 0.7 acre) waste disposal landfill, exists on the Walpole Island Indian Reserve. The site was used for an extended period of time, perhaps 30 years, for the disposal of domestic waste, junk (old cars etc.) and garage waste by island residents and summer cottagers. It was closed and covered over in 1976 because of health concerns due to its proximity to some residences.

The land is very flat and lowlying, only a couple of meters above the nearby St. Clair River. The water table is close to the surface (< 1.5 m/4.9 ft deep) and the local geology consists of deltaic sands and silts.

A synopsis by Environment Canada indicates evidence of leachate, however, the report does not disclose its nature. Leachate migration off-site is likely due to both surface runoff and subsurface seepage to the water table.

26. County of Lambton Landfill Sites

As of January 1, 1991, the County has assumed responsibility for six landfill sites (including the City of Sarnia Landfill). These landfills are summarized in Table 8.40. The Town of Petrolia landfill site was purchased by a private company.

8.3.1.2.3 Ontario Underground Injection Wells

In Lambton County, Ontario, deep injection wells were used to dispose of industrial wastes during the period 1958-1972 and are still used for the disposal of cavern brines and oil field brines (UGLCCS 1988). There are about 35 deep wells in Lambton County (Figure 8.5). The Lucas Formation of the Detroit River Group (see Chapter 5) was heavily utilized prior to 1976 for the injection of industrial waste. The freshwater aquifer lies above this bedrock, therefore the potential exists for wastes to flow upwards into the aquifer and thus migrate to the St. Clair River.

The industrial waste wells were located in three areas. The most heavily utilized area was the industrialized section south of Sarnia, adjacent to the St. Clair River. In this location, wells were used by Esso Petroleum Canada (5 wells), Shell Canada Ltd. (2 wells), Suncor Inc. (1 well) and Polymer Corp. (1 well) (Figure 8.5).

In addition, Dow Chemical Canada Inc. has two wells which access storage salt caverns in the Salina formation which occurs at a much deeper level than the Detroit River Group.

Table 8.40 Approved area and remaining capacity of existing municipal waste landfills (OMOE 1990b).

Site	Approved Site Area ha (acres)	Estimated Waste to Site - tonnes (tons) (Jan. 1, 1989)	Estimated Capacity Remaining - tonnes (tons) (Jan. 1, 1989)	Estimated Remaining Site Life (years)
Lambton Brooke	2.5 (6.2)	8,030 (8,849)	10,280 (11,329)	17+
Lambton Dawn	14.48 (35.8)	9,000 (9,918)	53,740 (59,221)	100+
Lambton Grand Bend	4.05 (10)	26,300 (28,986)	0	0
Lambton Moore	18.0 (37)	55,020 (60,632)	63,050 (69,481)	6+
Petrolia (private)	26.02 (64.3)	136,460 (150,379)	2,145,540 (2,364,385)	100+
Lambton Sarnia	21.0 (51.9)	1,255,600 (1,383,671)	128,000 (141,056)	1.5+
Lambton Sombra	4.5 (11.1)	23,210 (25,577)	0	0
Laidlaw-Warwick (private)	32.4 (80)	204,650 (225,524)	950,000* (1,046,900)	14+*

Note: Estimates are based on current certification, configuration, approved area, waste restrictions and present operating practices.

* Capacity for all wastes entering the landfill, not just municipal waste. Based on verbal communication with M. Walters, Laidlaw Waste Management Systems Ltd., 23 November 1989.

The second area is located inland from the river and included the well of Marcus Disposal (1 well), Thompson Wright Co. (2 wells), and Laidlaw (formerly Tricil-Goodfellow) (2 wells). A third area is found in Courtright adjacent to the St. Clair River, and consists of 2 wells belonging to ICI Nitrogen Products.

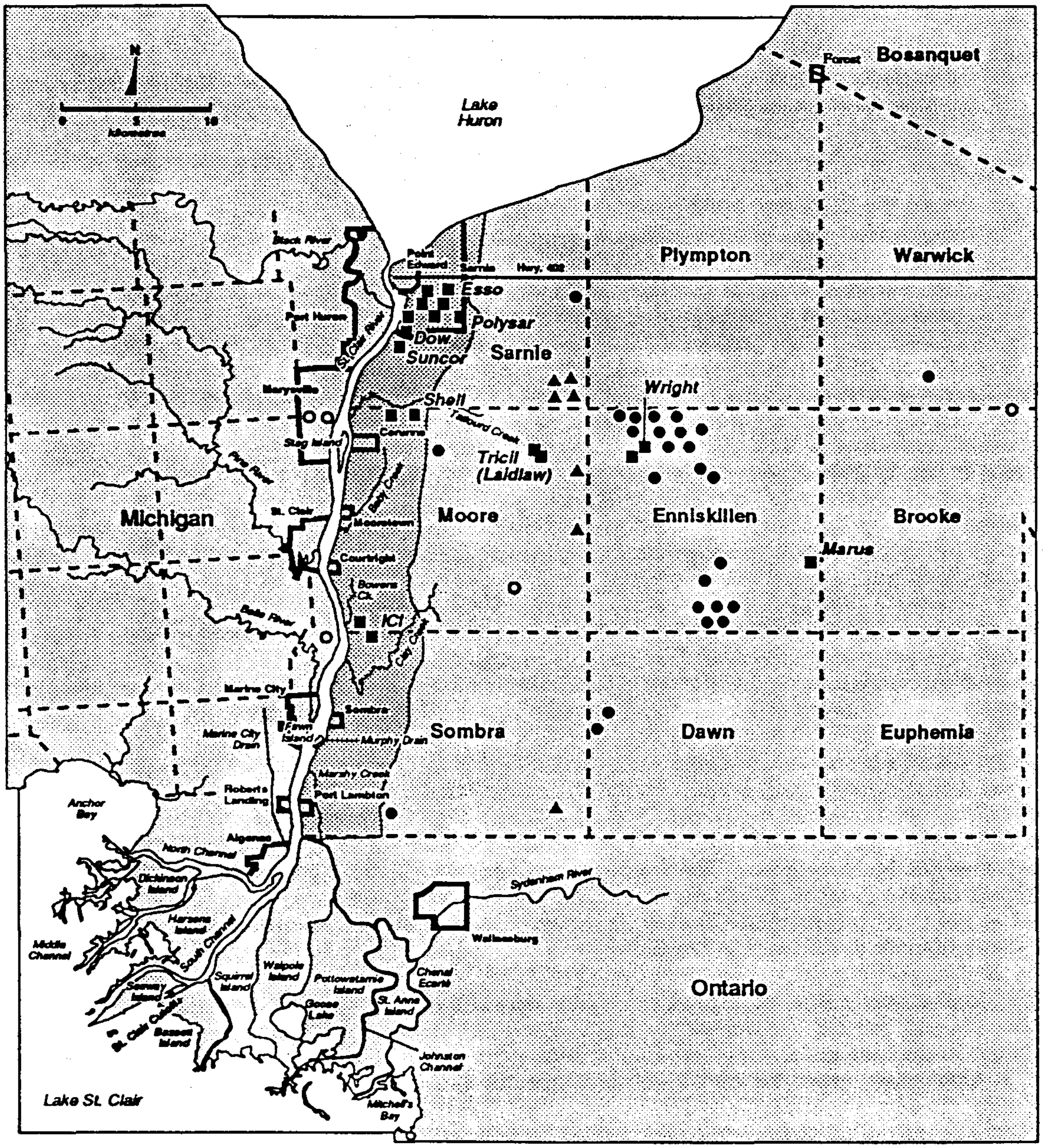
The Primary waste types disposed in the wells were spent caustics, acids, phenols, minor hydrocarbons, and now, brine. The volumes of industrial wastes injected into the bedrock (Detroit River Group, see Chapter 5) total 7,513,722 m^3 (1,950 X 10^6 U.S. gal). In the industrial area of Sarnia, it was usually necessary to inject waste under pressure to achieve the required injection rate. The wells close to the St. Clair River often required pressures up to 3,103 kPA (450 psi) at surface to inject the waste. The average injection pressure was 2,758 kPa (400 psi).

Cambrian Disposal Ltd. owned and operated 7 wells in Lambton County for the disposal of cavern-washing brine waters. Between 1971 and 1985, the total volume of waste injected under gravity into these wells, was 10,194,889 m^3 (2,652 X 10^6 U.S. gal). All wells used for the disposal of brine materials have established monitoring well networks on adjacent properties to determine water quality in the freshwater aquifer. The company is also required to pay a levy for each cubic metre of waste injected to cover the perpetual care of the well once it is abandoned.

Figure 8.5

St. Clair River Remedial Action Plan

Location of waste disposal wells



■ Liquid industrial waste - injections discontinued
▲ Cavern-Washing Brine injected into the Detroit River Group
● Oil-Field Brine injected into the Detroit River Group
O Oil-Field Brine injected into the Guelph Formation
▒ All waste injections prohibited (8 km in from St. Clair River)
- - - Township line

The past practice of injection of industrial wastes into the Detroit River Group and the potential for contamination of the freshwater aquifer were identified by UGLCCS (1988) as a concern. Because of the high pressures used for injection and the large volumes of wastes, the potential exists for contaminants to migrate from the disposal unit to the freshwater aquifer and hence, to the St. Clair River. The possible pathways of migration include the following:

1. numerous exploratory bore holes have been drilled in search of oil or gas. Many of them were abandoned without proper closure and thereby provide open conduits through the bedrock to potable water aquifers if the lower formations are under excessive pressure;

2. poorly constructed injection wells could allow waste to migrate along the outside of the casing;

3. faults, fractures and joints are likely to exist in the bedrock confining units and it is possible the pressurized waste could travel great distances via these fractures; and

4. the permeability of the confining shale and limestone units may be of sufficient magnitude to allow pressurized wastes to migrate via pore spaces to the shallow aquifer.

In view of the possible migration pathways and the fact that there were documented cases of upwelling in the Sarnia area via open bore holes between 1966 and 1972, there was the possibility that the groundwater system had been pressurized above its natural state. This being the case, it was possible that the displacement of formation fluids, or the upwelling of industrial wastes, may have contaminated the freshwater aquifer in the St. Clair River area or have migrated across the St. Clair River to Michigan.

Detailed studies of the freshwater aquifer and the movement of injected wastes were undertaken from 1986 to late 1988 by the federal and provincial governments, and industry. The results of these studies were reported by Intera Technologies Inc. (1989).

This study included the drilling, testing and installation of fifteen groundwater monitoring wells to the freshwater aquifer and one 300 m (984 ft) deep borehole to the disposal formation in the Detroit River Group of formations as well as quarterly groundwater sampling and hydraulic head monitoring of a 29 point monitoring well network of the freshwater aquifer and of the deep borehole.

The results of this study show that the freshwater aquifer is a thin, discontinuous aquifer located at or near the bedrock surface with an average hydraulic conductivity of 5×10^{-6} m/sec (16.4×10^{-6} ft/sec). A buried bedrock valley of depth 60 to 80 m (197 to 262 ft) below ground surface and 30 to 40 m (100 to 130 ft) below the surrounding bedrock surface is located about 500 to 1000 m (1,640 to 3,280 ft) east of the current channel of the St. Clair River. The freshwater aquifer has a higher hydraulic conductivity within the bedrock valley due to the presence of coarser material. The freshwater aquifer is generally overlain by 30 to 70 m (100 to 230 ft) of low permeability clay till, however, below the St. Clair River the thickness of confining till, in places, may be as thin as 3 m (10 ft).

Groundwater flow within the freshwater aquifer toward the bedrock valley averages 0.57 m^2/year (0.68 yd^2/year) per unit aquifer width. Within the bedrock valley some flow is directed down to deeper geologic formations and some of the flow is discharged to the St. Clair River. No groundwater flows under the St. Clair River within the freshwater aquifer to the U.S.

Phenol contamination of the freshwater aquifer by injected industrial waste is evident on the Esso Petroleum Canada property near the St. Clair River and below the St. Clair River in the area of the CN Railway tunnel. Loading to the St. Clair from this 800 m (2,624 ft) by 600 m (1,968 ft) contaminated zone is calculated at only 0.0052 kg/d. Chloride contaminant loading to the River from the same area is calculated at 50 kg/d.

It is recognized that some undetected contaminant plumes may exist in the vicinity of disposal wells due to waste migration up abandoned boreholes. Assuming such plumes did exist adjacent to the St. Clair River, the total potential phenol loading to the River is estimated at 0.025 kg/d. This would result in an increase in phenol concentration in the River of 1.9 ng/L which is about 500 times less than the minimum detection limit of 1 μg/L (UGLCCS 1988).

Industrial waste characterized by phenols (30,000-40,000 $\mu g/L$) volatile organics (e.g., benzene, toluene, etc., 200-5,800 $\mu g/L$) and naphthalenes (50-829 $\mu g/L$) is restricted to a narrow 11 m (36 ft) interval in the upper section of the Lucas dolomite. Vertical migration of this waste through the pore space of the overlying and underlying rocks has been negligible and measured hydraulic heads show fluid flow in the adjacent rocks is now toward the disposal zone. Current overall flow directions are from the freshwater aquifer and St. Clair River to the disposal zone.

A significant finding of this study was the occurrence of high hydraulic conductivity limestone layers in the Hamilton Group of formations at 74 and 123 m (243 and 403 ft) depth that likely contain industrial waste at phenol concentrations of 6,000 - 10,000 $\mu g/L$ and hydraulic heads above those in the freshwater aquifer. The 2 m (6.6 ft) thick limestone layer at 74 m (243 ft) depth is of particular concern to this study because groundwater from this horizon likely discharges to the freshwater aquifer within the bedrock valley and this horizon flowed industrial waste in 1967 and 1969 at rates of 10 to 238 L/min (2.6 to 61.9 U.S gal/min). The extent of contamination in this and the 123 m (403 ft) depth horizon is not known, however, the two monitoring wells to these horizons detected industrial waste. This waste was likely introduced to these limestone horizons during the period of pressure injection as a result of improperly completed disposal, cavern or abandoned wells.

Since pressurized liquid injections to the Detroit River Group was terminated in 1976, vertical migration of this liquid waste to overlying layers has ceased (Intera Technologies 1989).

8.3.1.3 Michigan Waste Disposal Sites and Landfills

There are seven sites of environmental contamination in St. Clair County, Michigan that are listed on the Priority List for EVALUATION AND INTERIM RESPONSE under Act 307. Under this Act, each site undergoes a Site Assessment System (SAS) evaluation to determine the relative severity of contamination based on known or potential impacts to human health and the environment. Scores from this assessment determine the priority of the site. The responsibility for the cost of all response activities lies with the those responsible for the contamination except when funds cannot be collected from, or a response activity cannot be undertaken by, the responsible party.

Six sites are in close proximity (within 3 mi or 4.8 km) to the St. Clair River, and MDNR file information indicates some potential for surface water contamination from the sites. These sites of environmental contamination are:

1 Hoover Chemical/Reeves Product
2 St. Clair Rubber Wills Street Dump
3 Winchester Disposal
4 A & B Waste Disposal
5 John A. Biewer Company Inc.
6 River Road Contamination Site

Brief summaries of the six "307 sites", and actions completed to address contamination at the sites follow. Their locations are shown in Figure 8.4.

1. Hoover Chemical/Reeves Product

Hoover Chemical is a paint manufacturer that leases space to Reeves Products for processing by-products for sale. Reeves also purchases paint and solvents for resale. The Hoover Chemical/Reeves Products site is located on the outskirts of Port Huron, 0.8 km (0.5 mi) from the St. Clair River and Bunce Creek, and 610 m (2,000 ft) from Pickard Drain (Figure 8.4). The site is 0.5 ha (1.33 acres) in size.

Waste at the Hoover Chemical/Reeves Products site consisted of 1500 drums (215 L or 55 U.S. gallons each) of solvents (MDNR unpublished data, 1985). Many drums found at the back of the site were situated on the bare ground and were observed to be bulging, corroded and leaking (MDNR unpublished data, 1984). Sample results showed that the solvents contained 12 heavy metals including arsenic (3.1 $\mu g/g$), cadmium (6.6 $\mu g/g$), lead (21,685 $\mu g/g$), manganese (111 $\mu g/g$), mercury (0.13 $\mu g/g$) and chromium (4,140 $\mu g/g$) (MDNR unpublished data, 1985). Contaminated soil patches were observed throughout the site. Soil samples revealed both organic and inorganic contaminants (MDNR unpublished data, 1984).

The groundwater in this area is protected by a thick clay layer. However, the potential for groundwater contamination exists. Groundwater flows easterly, towards the St. Clair River (MDNR unpublished data, 1984).

Surface water contamination was observed at the Hoover Chemical/Reeves Products site in 1984 when leaky drums were found near a white-coloured pond (MDNR unpublished data, 1984). A marshy area behind the site eventually drains to the St. Clair River. The extent of surface water contamination has not been determined. The City of Marysville's water intake is within 2.5 km (1.5 mi) downstream of the Hoover Chemical/Reeves Products site (MDNR unpublished data, 1984).

In 1986, a work plan and a $221,971 request from the Act 307 fund were approved to conduct a remedial investigation at the Hoover Chemical/Reeves Product site. As of November 1986, 42,900 L (11,000 U.S. gallons) of liquid from drums had been removed from the site and 595 drums had been sampled (MDNR unpublished data, 1986). One of the potentially responsible parties agreed to sample and dispose of 1200 drums of surplus paint and resins (MDNR unpublished data, 1987).

2. St. Clair Rubber-Wills Street Dump, Marysville

The St. Clair Rubber-Wills Street Dump site is an inactive, uncapped dump covering approximately 0.8 ha (2 acres). It was unlicensed and active for an unknown number of years. The St. Clair Rubber Company illegally disposed of its waste at this site during the period 1970-1979, according to two former employees of the company (MDNR unpublished data, 1986). The site is located in a rural, lightly industrialized area 1.6 km (1 mi) south of Marysville and 400 m (1,320 ft) west of the St. Clair River (Figure 8.4). The dump is uncovered, heavily vegetated and approximately 200 m (650 ft) from a wetland. Two fluid lagoons are on-site. The lagoons are not dyked and it is not known if they are lined.

Waste on-site includes rubber piles; rusted, corroded, empty drums; and unknown buried waste. Test pitting was performed on the site in 1987 to assess the nature and volume of buried waste (MDNR unpublished data, 1988). Approximately 3,875 m^3 (5,100 yd^3) of non-hazardous rubber waste and an unknown number of drums are buried. Orange waste inside one drum was sampled and found to be hazardous (lead > 5,000 $\mu g/L$) per the extraction procedure toxicity analysis. Other buried waste was found to be non-hazardous. The dump is surrounded by a fence with a locked gate, but a mound of discarded rubber and scattered empty drums were observed outside the fence.

Soil samples were collected in 1986. Results showed no inorganic contaminants at levels significantly above background sample levels. Low levels of 1,1-dichloroethane, 1,1,1-trichloroethane and toluene were found in soil samples from the site. Phenols (0.847 $\mu g/g$ and 1.587 $\mu g/g$) and the PCB Aroclor-1260 (0.320, 2.300 and 3.400 $\mu g/g$) were also found in on-site samples (MDNR unpublished data, 1986).

Surface water potentially affected includes a wetland which is 200 m (660 ft) west of the site, and the St. Clair River. The fluid lagoons may have overflowed to a surface water ditch adjacent to the property that has a direct connection to the St. Clair River. Wetland flora and fauna may potentially be damaged by possible surface water, groundwater and soil contamination.

3. Winchester Disposal, Port Huron

Winchester Disposal is a 16 ha (40 acre) site that was licensed in the 1950s as a junkyard. The site has allegedly been used as a dump for 25 to 30 years but was never licensed as one (MDNR unpublished data, 1984). The site is located in a sparsely populated area on the western outskirts of Port Huron, less than 5 km (3 miles) west of the St. Clair River (Figure 8.4). As of February 1989, tires, empty barrels (which are suspected of having contained liquid at the time of disposal), household appliances, and other refuse were found on the site. The site is not fenced and is easily accessible. There is evidence of recent dumping. The total amounts and types of waste at Winchester Disposal are not known (MDNR unpublished data, 1984, 1986 and 1989).

Soil contamination was observed in 1978 when MDNR reported that phenolic resins had been dumped on the ground. Shallow groundwater contamination was observed at the Winchester Disposal site in 1981. Results of shallow monitoring well sampling revealed heavy metal contaminants including cadmium (0.04 mg/L), copper (2.96 mg/L), lead (1.5 mg/L), zinc (5.1 mg/L) and iron (2,510 mg/L) (MDNR unpublished data, 1986). Contamination is probably limited to the shallow groundwater; a 30 m (100 ft) continuous clay layer protects a deeper aquifer. Groundwater flow is to the southeast (MDNR unpublished data, 1986).

Samples taken in March 1990 show surface water contamination of wetlands surrounding the site. Areas northeast of the site are contaminated with vinyl chloride (1900 μg/L) and trans-1,2-dichloroethylene (4,200 μg/L). Samples taken to the west of the site contained tetrachloroethylene (3 μg/L). Vinyl chloride and trans-1,3-dichloropropylene were found east of the site in concentrations of 52 and 680 μg/L, respectively. The wetlands drain to Bunce Creek which flows to the St. Clair River. The extent of possible contamination of these waterbodies is not known (MDNR unpublished data, 1989). Three monitoring wells were installed in 1990 into the shallow aquifer. The results show contamination by methylene chloride at concentrations of 6 μg/L and acetone at 8 μg/L. Further studies to determine the extent of contamination at this site have been funded by the MDNR for fiscal year 1992.

The Winchester Disposal site property was deeded back to the State of Michigan by Port Huron Township and a private partners group (the site had been previously deeded to Port Huron Township by the State of Michigan). Port Huron Township Economic Development Corporation has a land contract agreement with Grand Trunk Railroad for the western portion of the site.

In 1990, the site underwent a surface cleanup where over 1,600 drums were removed, 286 with contents. Over 21 percent of the waste removed was hazardous for flash point PCBs and heavy metals. The remaining tires, over 180,000, were shredded and left on-site. At present, the U.S. Army Corps of Engineers is placing over 49,000 m^3 (65,000 yds^3) of dredge materials from the Black River over the shredded tires and much of the uncovered landfill materials that are exposed on-site. The composition of the dredge material was reviewed by the U.S. EPA and the MDNR and was found to be acceptable for placement at this site.

4. A & B Waste Disposal, Port Huron

A & B Waste Disposal is a transfer station where waste is sorted for recycling/resale or disposal. It is located near Port Huron, approximately 0.8 km (0.5 mi) west of the St. Clair River (Figure 8.4). The site's estimated size is 1.6 ha (4 acres).

MDNR staff conducted a site assessment in November 1983. An estimated 14,714 m^3 (19,360 yd^3) of waste was observed on the ground surface. Substances possibly present included paint solvents, household garbage, demolition waste and fly ash. All surface refuse was cleared from the site as of July 31, 1984 (MDNR unpublished data, 1984).

Soil samples were collected in October 1984. Test results showed a variety of solvents, heavy metals and organic compounds were present. Approximately 57 to 60, 55 gallon (211.5 L) drums were found above-ground at that time. Some drums were described as "opened and bulged" with solidified substances on the surrounding ground (MDNR unpublished data, 1984). The site remains a potential source of soil and groundwater contamination, due to past exposure to surface rubbish and post-cleanup dumping or leaking from storage drums. The extent of soil contamination is not known (MDNR unpublished data, 1984).

A & B Waste Disposal is listed as a potential source of surface water contamination due to its proximity to the St. Clair River, Bunce Creek and Pickard Drain. The distances from the site to these waterbodies are 915 m (3,000 ft), 915 m (3,000 ft) and 610 m (2,000 ft), respectively. The water table is 4.5 to 6 m (15 to 20 ft) below the site's surface and the groundwater flow is easterly (MDNR unpublished data, 1984). The City of Marysville takes its drinking water from the St. Clair River within 1.5 km (1 mi) of the A & B Waste Disposal site. Therefore, the site is listed as having a potential to contaminate a drinking water supply.

5. John A. Biewer Company, Inc., St. Clair

The John A. Biewer Company, Inc. site is an active Wolmanizing plant located within a few miles of the St. Clair River, near the town of St. Clair (Figure 8.4). Wood treated with chromic acid, cupric oxide and arsenic pentoxide is dried in the open, over drying pads. Waste from the drying process is collected in a single pit via drainage ditches throughout the site. A sludge containing copper arsenic and chromium forms in the bottom of the collection pit, and is periodically removed from the site by a licensed hauler. An estimated 112.5 m^3 (148 yd^3) of sludge was present in the collection pit at the time of a February, 1984 site inspection (MDNR unpublished data, 1984). Although concrete drying pads are used, chemicals may drip onto bare soil if wood is removed from drying pads before it is completely dry.

Greenish discoloration of the soil was noted during the 1984 inspection indicating a potential for soil and groundwater contamination. Drainage leading to the collection pit crosses roads in the yard area and vehicles entering or leaving the site may distribute the chemicals (MDNR unpublished data, 1984).

An unknown number of people could potentially come in contact with chemicals stored on-site. Although locked gates protect driveways, there is no fence around the perimeter of the site. The buildings house chemicals and preserved lumber is stored in the yard (MDNR unpublished data, 1984).

The John A. Biewer Company, Inc. site is a potential source of surface water contamination. Waste dripped on the yard or picked up by tires may enter a drainage ditch that runs beside the yard. This ditch flows to the St. Clair River.

As of October 1984, no funding was available for this site and no action had been taken (MDNR unpublished data, 1984).

6. River Road Contamination Site

The site known as the River Road Contamination Site is located on River Road in Marysville, Michigan along the St. Clair River. This site is a vacant lot of approximately 4 ha (10 acres). It was once part of an industrial firm that had conducted various solid waste management activities. A site investigation was conducted and results revealed extensive soil and groundwater contamination. The site is contaminated with various metals, volatile organics, halogenated hydrocarbons, pesticides, and other potentially hazardous substances. Also, paint-like wastes, solid wastes such as metal bands, crushed drums, and batteries were found in the soils. Volatile and semi-volatile organics were found in the groundwater. The responsible party is currently completing the remedial investigation/feasibility studies to determine the extent of contamination and to develop a remedial action plan.

Other St. Clair County Landfills

There are 21 landfill sites located in St. Clair County. These are shown in Figure 8.4 and Table 8.41 identifies the type and status of each landfill. Only four of the landfills are open and operating. These are the Fort Gratiot, Huron Development, Range Road Property and Smiths Creek Landfills.

Fort Gratiot Landfill lies next to the Howards Disposal Landfill along Keewahdin Road. Inorganic parameters such as sodium, chloride, sulfate and calcium have increased in concentration over the past few years in samples taken from two monitoring wells located east of the Fort Gratiot Landfill. Sodium and chloride are elevated along the Keewahdin Road ditch south of the Fort Gratiot Landfill. Leachate outbreaks, which drain into a retention pond, occurred in 1990. The pond was extensively sampled before Waste Management Division and Surface Water Quality Division (MDNR) allowed discharge from the pond to the drain north of the facility. MDNR is currently investigating to determine the cause and possible solutions to these problems. These problems do not have an identifiable effect on the Carrigan Drain or Lake Huron.

Table 8.41 Operating status and type of landfills located in St. Clair County, Michigan.

Landfill	Type[1]	Status
Belle River Berm Project	3	closed
Blue Water Construction	3	closed
Clay Township	2	closed
Fort Gratiot	2	open
Howards Disposal	3	closed
Huron Development	2	open
Lynn Township Dump	3	closed
Norman Markel	3	closed
Range Road Property	3	open
Smiths Creek	2	open
Sanitary Landfill Area #2	2	closed
Vlasic Foods Inc.	2	closed
City of Algonac	2	closed
County Line	2	closed
Yale Sanitary Landfill	2	closed
Angus Cameron Dump	Dump	closed
Green Salvage Co.	Dump	closed
Ira Township	Dump	closed
City of Memphis	2	closed
Richmond Hills		closed
Wales Township	Dump	closed

1 'Type 2' means on-land disposal facility designed and operated to accommodate general types of solid waste, including, but not limited to, garbage and rubbish, but excluding hazardous waste. 'Type 3' means an on-land disposal facility designed and operated to accommodate large volumes of certain solid waste having minimal potential for groundwater contamination. 'Dump' refers to a landfill that was constructed prior to Act 641, *Solid Waste Management Act* P.A. 1978.

Smiths Creek Landfill is currently under a consent order from MDNR. The site had leachate outbreaks and an inadequate monitoring program in 1989. The leachate outbreaks have since been eliminated from some cells due to construction of a perimeter leachate collection system, and the monitoring program has been updated. The site still has leachate outbreaks on its east side. The landfill has an NPDES permit to discharge leachate from treatment ponds to Smiths Creek twice per year. MDNR will sample the groundwater, Wolvin Drain and Smiths Creek Drain in order to evaluate what effect, if any, the site has on groundwater or surface water. This sampling is planned during May, 1991.

Huron Development Landfill as well as the Belle River Berm Project and Range Road Property (the latter two are Detroit Edison Coal Ash Monofills) have had no identified effect on surface water. These sites do not have groundwater monitoring wells because of the presence of extensive clay.

8.3.2 Spills

8.3.2.1 Ontario Spills

Ontario's Environmental Protection Act defines "spills" as the discharge of pollutants into the natural environment originating from a structure, vehicle or other container, that are abnormal in both quantity and quality in light of all circumstances. Spills discussed in this section deal with those which have been reported to the Ontario Ministry of the Environment. They are primarily from industrial sources. Section 8.3.6 deals with spills which originated from ships in the St. Clair River. There are other potential sources of spills such as from ship collisions in the river, vehicles crossing the Blue Water Bridge, railcars utilizing the CN tunnel and petroleum pipelines which cross the river. The data currently available from OMOE and MDNR do not identify any recent incidents based on these kinds of sources.

The 1985 tetrachloroethylene spill (also referred to as perchloroethylene) was another incident within a history of accidental spills. The 54" sluice sewer was the route of discharge for this spill which originated at a loading area near the solvents plant. A valve on a catch basin tributary to the sluice, the basin being meant to hold such a spill, was seized in the open position, thus allowing the pure solvent to escape to the river (11,000 L/2,860 U.S. gal of a total spill of 30,000 L/7,800 U.S. gal reached the river) (OMOE 1990b).

This incident prompted a major investigation on the biological effects of spills and related discharges (Environment Canada/Environment Ontario 1986). The results of the study demonstrated that the waters, sediments, and biota of the St. Clair River system were adversely affected by discharges of contaminants to the river, and that the tetrachloroethylene spill aggravated an existing condition.

The tetrachloroethylene spill was not an isolated event. Rather, it was simply another incident in a long history of accidental spills. The data presented in the Upper Great Lakes Connecting Channels Study final report (1988) indicate that, on the Canadian side, 11 major oil spills of 10 tonnes (11 tons) or more (a total of 1,282 tonnes/1,413 tons) and 21 major spills of other hazardous compounds (a total of 10,390 tonnes/11,450 tons) occurred between 1974 and 1985. UGLCCS (1988) concluded that chemical and oil spills into the river can result in shock loadings in amounts equal to or greater than annual loads from ongoing regulated discharges.

Figure 8.6 illustrates the number of large contaminant spills (more than 10 tonnes/11 tons) between 1974 and 1989 from Ontario sources. Overall, there is a trend toward fewer such spills with a marked decrease from 1986 to 1988. However, the occurrence of two large spills in 1989 is of concern. One of these 1989 spills resulted in the loss of 8,500 kg of Selexol solvent containing dimethylether of polyethyleneglycol from I.C.I. Nitrogen Products. If the Selexol was discharged to the river as a continuous point source discharge, over a period of one year this spill would be equivalent to a loading of 35.6 kg/d.

Figure 8.7 illustrates the total number of spills between 1986 and 1989 from Ontario sources along with their OMOE classification. An "abnormal discharge" is defined as the discharge of a pollutant designated by regulations at a location (also designated by regulations) where the pollutant is deemed to be in a quantity or quality that is abnormal for that location. A "reportable spill" is one which has caused or is likely to cause an adverse effect.

Figure 8.6

St. Clair River Remedial Action Plan

Number of spills from Ontario sources to the St. Clair River of 10,000 kg or more of contaminant

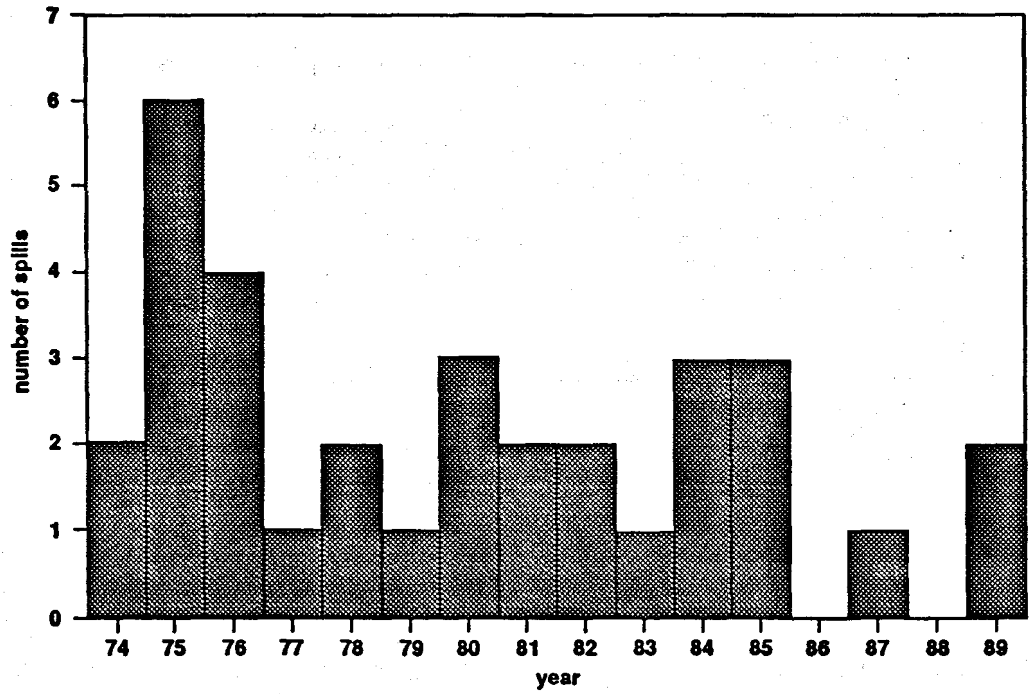
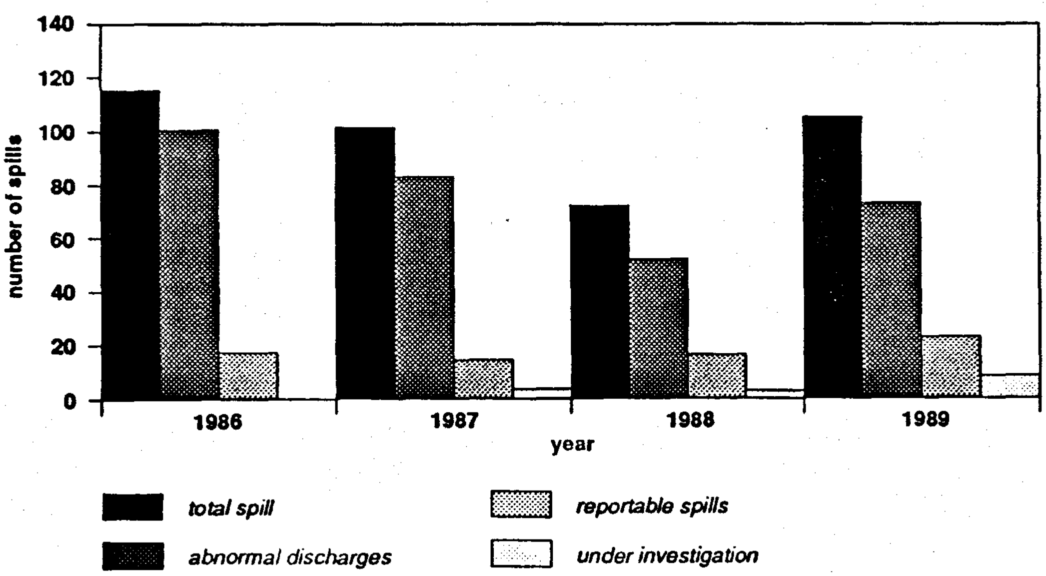


Figure 8.7

St. Clair River Remedial Action Plan

Total number of spills to the St. Clair River from Ontario industries from 1986 to 1989



The total number of spills to the St. Clair River has not changed appreciably over the period 1986 to 1989 (Figure 8.7). Two of the four years experienced in excess of 100 spills with only 1988 having less than this amount. The complete list of spills by date and company is included in Appendix 8.3.

Table 8.42 summarizes the spill data from Appendix 8.3 by substance spilled and year. Contaminant amounts were calculated from known concentrations of the substance within the material spilled. For example, many spills consist of wastewater or storm event overflows. Where the concentration and type of contaminant is known the total mass of the contaminant of interest was calculated. The total amount of the spill may in fact be much greater. This provides a basis for comparing loadings of contaminants from spills with other sources. As noted above for the 1989 I.C.I. spill of Selexol solvent, individual spills can contribute much greater quantities in one event than ongoing discharges in one year. The two spills of acetonitrile from Polysar in 1987 (Table 8.42) equates to an annualized discharge of 63 kg/d.

Spills of other contaminants of concern such as phenolics tend to be quite low. The total reported phenolics loading to the St. Clair River from spills for the four year period is only 28.7 kg or the equivalent to an ongoing discharge of only 0.02 kg/d. This is comparable to ongoing loads reported from Novacor Chemicals (Canada) Ltd, Corunna from its effluent during 1988. The largest group of pollutants spilled to the river are oil and gas products (Table 8.42). Although representing a mix of substances, the total mass of these products spilled from 1986 to 1989 was over 6,000 kg (not including the waste water spill from Esso in 1988) which equates to an ongoing loading of 4.12 kg/d every day for four years. This is in the range of effluent discharges of oil and grease from Polysar/Nova during 1989. Relatively large loadings of ammonia and ammonia-contaminated material and brine wastes are also spilled to the river each year (Table 8.42).

Comparisons between annualized loadings and individual spill events are provided in order to compare quantities of material using comparable units (kg/d). It should be noted, however, that shock loadings of contaminants from spill events may result in acute biological effects whereas smaller continuous discharges may result in chronic or sublethal biological effects.

8.3.2.2 Michigan Spills

The MDNR Pollution Emergency Alert System (PEAS) receives reports of all types and quantities of spills, accidents, discharges, and problems related to pollution. PEAS calls are routed to MDNR district offices Monday through Friday 8:00 a.m. to 5:00 p.m. (business hours) and to MDNR Lansing office personnel during non-business hours. The information provided in this section is a subset of all PEAS calls received as follows:

November - December	1986:	non-business hours log only
	1987:	non-business hours log only
	1988	business and non-business hours logs
	1989:	business and non-business hours logs
January - June	1990:	business hours log only

During this time, 187 complaints potentially affecting the St. Clair River or its tributaries were made through PEAS (Appendix 8.4). Approximately 69 percent of these complaints specified the St. Clair River as the affected waterbody. Tributaries to the St. Clair River cited by PEAS callers included the Black River (7.5%), the Belle River (5.9%) and the Pine River (3.2%). Substances released were generally identified, but in 67 percent of the calls the amount of the substance lost was not known. Known to be released were 26,330 kg (58,000 lbs) of chemicals and 2,180,769 L (567,000 U.S. gal) of various pollutants. Table 8.43 lists spills of hydrocarbons, various chemicals, effluents and raw or partially treated sewage to the St. Clair River and its tributaries from Michigan sources between November 1986 and June 1990. Appendix 8.4 lists each spill by date.

Over 30 percent of the PEAS calls cited oils, oil sheens, and oily substances as pollutants. Over 44 percent of the callers cited the location of the "oily" pollutant as near the cities of Port Huron or St. Clair (Appendix 8.4).

Table 8.42 Pollutant loading contributions to the St. Clair River from selected spills as reported to OMOE for the period 1986 through 1989 (OMOE 1990b). (Refer to Appendix 8.3 for complete list of spills). Amounts shown represent portion not contained or recovered. (Weight calculated from reported volumes on the basis of the density of water ($1g/cm^3$).

SOURCE	SUBSTANCE SPILLED	YEAR	AMOUNT (kg)	FREQUENCY (NUMBER OF SPILLS)
DOW	BENZENE	1986	36.00	1
DOW	ETHYLBENZENE, CRUDE	1986	660.00	1
DOW	ETHYLBENZENE/STYRENE	1986	39.00	1
POLYSAR	POLYETHYLBENZENE IN CONTAMINANTS	1986	42.75	1
DOW	ETHYLBENZENE/STYRENE	1987	690.00	1
POLYSAR	BENZENE	1988	<38.00	1
POLYSAR	ETHYLBENZENE IN WATER	1988	NA	1 *3
ESSO PETRO	BENZENE	1989	37.40	1 *1
POLYSAR	BENZENE	1989	40.79	4 of which 1 *5
SUNCOR	BENZENE	1989	16.00	1
POLYSAR	DIETHYLBENZENE	1989	93.00	1
ESSO PETRO	ETHYLBENZENE	1989	14.90	1 *1
DOW	ETHYLENEDICHLORIDE	1986	120.00	1
POLYSAR	CHLORIDE, ALUMINUM	1988	3.00	1 *4
POLYSAR	CHLORIDE, METHYL	1988	272.00	1 *4
ETHYL	ETHYLCHLORIDE	1989	30.66	1
DUPONT	BIPHENYL-BIPHENYLETHER	1987	2.00	1
DUPONT	BIPHENYL-BIPHENYLETHER	1988	3.00	1
DUPONT	BIPHENYL-BIPHENYLETHER	1989	3.00	2
TOTAL DOWTHERM			8.00	
DOW	FeO/SAND	1987	230.00	1
ICI	AMMONIUM CARBAMATE	1986	20.00	1
ICI	DI-AMMONIUM PHOSPHATE	1986	NA	1
ICI	AMMONIA IN STORM WATER	1987	3.64	1
ICI	AMMONICAL NITROGEN	1987	53.22	3
ICI	AMMONIA, ANHYDROUS (50%)	1987	3.50	1
ICI	AMMONIA, AQUEOUS (33%)	1987	75.01	1
ICI	AMMONIUM CARBAMATE	1987	27	2
ICI	WASTE WATER (440 PPM NH3)	1987	239.71	1
POLYSAR	AMMONIA	1988	2124.00	1
ICI	AMMONICAL NITROGEN	1988	40.00	2
ICI	AMMONIUM CARBAMATE	1988	9.00	1
ICI	AMMONIUM NITRATE	1988	262.00	1
ESSO PETRO	AMMONIA	1989	66.40	1 *1
POLYSAR	AMMONIA	1989	3000.00	1
POLYSAR	AMMONIA (1.6 PPM)	1989	0.02	1 *5
ICI	AMMONICAL NITROGEN	1989	219.00	3
LAMBTON HYDRO	AMMONIA, AQUEOUS	1989	0.32	1
ESSO PETRO	TOTAL PAHs	1989	3.50	1 *1
LAND	GASOLINE	1986	171.00	1
SHELL	HYDROCARBON	1986	67.5	18
SHELL	HYDROCARBON SOLVENTS	1986	4.00	1
POLYSAR	HYDROCARBON, AROMATIC	1986	1.00	1

Table 8.42 (cont'd)

SOURCE	SUBSTANCE SPILLED	YEAR	AMOUNT (kg)	FREQUENCY (NUMBER OF SPILLS)
SHELL	NAPTHA	1986	NA	1
SHELL	NAPTHA	1986	NA	1
ESSO PETRO	OIL	1986	NA	1
SHELL	OIL	1986	112.96	1
SUNCOR	OIL IN WATER	1986	0.45	1
UNKNOWN	OIL SHEEN	1986	NA	3
SUNCOR	OIL SHEEN	1986	NA	1
UNKNOWN	OILY SLUDGE	1986	22.73	1
POLYSAR	OILY WATER	1986	NA	1 *2
ESSO PETRO	OILY WAX	1986	4.54	1
POLYSAR	OIL, AROMATIC STYRENE	1986	0.24	1 *10
POLYSAR	OIL, COMPRESSOR	1986	100.00	7
ESSO PETRO	OIL, CRUDE	1986	6.82	1
SUNCOR	OIL, FURNACE, LIGHT	1986	13.64	1
SHELL	OIL, GASOLINE, HEAVY	1986	NA	1
LAND	OIL, HYDRAULIC	1986	45.46	1
ESSO PETRO	OIL, LIGHT	1986	NA	1
DOW	OIL, LUBE	1986	8.00	1
POLYSAR	OIL, LUBE	1986	8.00	1
POLYSAR	OIL, LUBE/COMPRESSOR	1986	20.00	3
UNKNOWN	OIL, LUBE/GASOLINE	1986	NA	1
LAMBTON HYDRO	OIL, TURBINE	1986	10.00	1
SHELL	DIESEL FUEL	1987	5.00	1
ESSO PETRO	GASOLINE	1987	1170.00	1
SHELL	GASOLINE	1987	29.25	1
SHELL	HYDROCARBON	1987	63.05	22 of which 1 *11
SHELL	NAPTHA	1987	9.09	1
ESSO PETRO	OIL	1987	NA	2
UNKNOWN	OIL	1987	NA	6
POLYSAR	OIL	1987	33.00	9 of which 2 *8
SHELL	OIL	1987	39.75	1
POLYSAR	OIL AND RUBBER	1987	4.00	1
UNKNOWN	OIL SHEEN	1987	NA	1
POLYSAR	OIL SHEEN	1987	34.5	1
SHELL	OIL SHEEN	1987	0.50	1 *11
ESSO PETRO	OILY WATER	1987	NA	1
FIBERGLAS	OIL, 20W20	1987	4.40	1
POLYSAR	OIL, AROMATIC EXTENDER	1987	12.50	1
SUNCOR	OIL, FUEL	1987	4.55	1
SHELL	OIL, GASOLINE, LIGHT	1987	3.00	3
ESSO PETRO	OIL, HEAVY	1987	0.22	1
DOW	OIL, LUBE	1987	3.30	1
ESSO PETRO	OIL, LUBE	1987	818.00	1
POLYSAR	OIL, LUBE	1987	56.8	7
SHELL	OIL, PRODUCT	1987	1.00	1
DOW	GASOLINE	1988	80.00	1

Table 8.42 (cont'd)

SOURCE	SUBSTANCE SPILLED	YEAR	AMOUNT (kg)	FREQUENCY (NUMBER OF SPILLS)
SHELL	HYDROCARBON	1988	19.32	10
SHELL	HYDROCARBON SOLVENTS	1988	20.00	1
SHELL	NAPTHA HEAVY	1988	9.00	1
ICI	OIL	1988	1.00	1
ESSO PETRO	OIL	1988	9.00	4
LAMBTON C F	OIL	1988	NA	1
UNKNOWN	OIL	1988	NA	1
POLYSAR	OIL	1988	10.00	3
SHELL	OIL	1988	2.00	1
UNKNOWN	OIL LIGHT SHEEN	1988	NA	1
UNKNOWN	OIL SHEEN	1988	NA	5
LAND	OILY WATER	1988	NA	1
POLYSAR	OILY WATER	1988	NA	1
ICI	OIL, COMPRESSOR	1988	255.00	1
SHELL	OIL, CRUDE	1988	20.50	1
SHELL	OIL, DIESEL, LIGHT	1988	23.00	1
ESSO PETRO	OIL, EMULSIFIED	1988	163.60	1
SHELL	OIL, GASOLINE, HEAVY	1988	159.00	1
ICI	OIL, HYDRAULIC	1988	7.00	1
LAND	OIL, HYDRAULIC	1988	35.00	1
DOW	OIL, LIGHT	1988	40.00	1
POLYSAR	OIL, LUBE	1988	4.00	1
UNKNOWN	OIL, OTHER	1988	NA	1
POLYSAR	OIL, OTHER	1988	32.50	1
POLYSAR	OIL, TRANSFORMER	1988	5.00	1
SUNCOR	DIESEL	1989	1.00	1
SHELL	GASOLINE	1989	NA	1
SHELL	HYDROCARBON	1989	7.50	7
SHELL	HYDROCARBON, AROMATIC	1989	NA	2
ESSO PETRO	OIL	1989	5.00	4
FIBERGLAS	OIL	1989	4.00	1
LIQUID CARBONIC	OIL	1989	150.00	1
LAND	OIL	1989	45.46	1
UNKNOWN	OIL	1989	1.50	5
SHELL	OIL	1989	1.00	1
SUNCOR	OIL	1989	2.00	2
UNKNOWN	OIL SHEEN	1989	NA	4
UNKNOWN	OIL SLICK	1989	NA	1
POLYSAR	OIL, AROMATIC	1989	17.50	2
SUNCOR	OIL, DIESEL	1989	454.60	2
SUNCOR	OIL, FUEL	1989	1000.00	1
SHELL	OIL, GASOLINE, LIGHT	1989	3.00	3
CABOT	OIL, HEAVY	1989	1.00	1
ETHYL	OIL, HYDROPOLYMER AND WATER	1989	150.00	1
DOW	OIL, LUBE	1989	81.00	2
ESSO PETRO	OIL, LUBE	1989	NA	1
POLYSAR	OIL, LUBE	1989	65.00	2
SHELL	OIL, LUBE	1989	4.55	1
POLYSAR	OIL, OTHER	1989	190.00	1
SHELL	OIL, STOVE	1989	5.00	2

Table 8.42 (cont'd)

SOURCE	SUBSTANCE SPILLED	YEAR	AMOUNT (kg)	FREQUENCY (NUMBER OF SPILLS)
ESSO CHEM	PHENOLICS	1986	NA	1
FIBERGLAS	PHENOLICS	1986	0.121	4
POLYSAR	PHENOLICS	1986	0.062	17 of which 1 *2 & 11 *9
FIBERGLAS	PHENOLICS	1987	NA	1
POLYSAR	PHENOLICS	1987	0.230	4 of which 3 *7
FIBERGLAS	PHENOLICS	1988	5.513	6
POLYSAR	PHENOLICS	1988	0.370	1 *3
SHELL	PHENOLICS	1988	17.000	1
DUPONT	PHENOLICS	1989	5.000	1
FIBERGLAS	PHENOLICS	1989	0.334	6
POLYSAR	PHENOLICS	1989	0.024	3 of which 1 *5 & 1 *6
TOTAL PHENOLICS			28.654	
ICI	PHOSPHORIC ACID (35%)	1986	35.00	1
ICI	ORGANIC PHOSPHATE	1989	150.00	1
ICI	DIMETHYLETHER OF POLYETHYLENEGLYCOL	1989	8500.00	1
ESSO CHEM	TOLUENE	1989	11.70	1
ESSO PETRO	TOLUENE	1989	7.10	1 *1
TOTAL TOLUENE			18.80	
ESSO PETRO	XYLENE	1989	8.10	1 *1
SUNCOR	XYLENE	1989	NA	1
POLYSAR	ZINC AND CALCIUM STEARATE	1986	5.00	1
ESSO PETRO	1-METHYL-2-PYRROLIDONE	1988	50	1
POLYSAR	ACETONITRILE	1987	15,600	2
POLYSAR	ACETONITRILE (5 PPM)	1989	0.0685	1
POLYSAR	ACRYLONITRILE	1989	0.5	1
DOW	AL/MG TITANIUM HYDROXIDE	1986	31	1
POLYSAR	AROMATICS	1989	10	2
ESSO PETRO	BIOX FEED	1989	9,816	1
NOVACOR CORUNNA	BRINE	1987	2,535,800	1
ESSO CHEM	BRINE	1989	100,000	1
ESSO PETRO	BRINE (25%)	1987	12,270	1
NOVACOR CHEM	ISOPROPANOL	1986	1,135.59	2
DOW	ETHYLENE GLYCOL	1986	50	1
FIBERGLAS	ETHYLENE GLYCOL	1986	12	1
POLYSAR	TERTIARY BUTYL ALCOHOL	1987	67,400	3
FIBERGLAS	ETHYLENE GLYCOL	1988	4	1
NOVACOR CHEM	ETHYLENE GLYCOL	1989	0.8	1
LAMBTON HYDRO	FLY ASH	1986	4,682.08	2
DUPONT	HYDROCHLORIC ACID	1987	25	1
DOW	HYDROCHLORIC ACID	1988	200	1
DOW	HYDROCHLORIC ACID	1989	45	3
LAMBTON HYDRO	HYDROCHLORIC ACID (4%)	1986	1.6	1
POLYSAR	STYRENE	1987	17.8	1
POLYSAR	STYRENE	1989	46.5	3
DOW	STYRENE	1989	300	1 *8
POLYSAR	TOC	1986	47.9	13 of which 11 *9 & 1 *10
POLYSAR	TOC	1987	161	8 of which 2 *8 & 3 *7
POLYSAR	TOC	1988	54	2

Table 8.42 (cont'd)

SOURCE	SUBSTANCE SPILLED	YEAR	AMOUNT (kg)	FREQUENCY (NUMBER OF SPILLS)
POLYSAR	TOC	1989	3.8	3 of which 1 *5 & 1 *6
ICI	UNTREATED POND WATER	1987	1,136,500	1
ICI	ACIDIFIED WATER	1987	44,000,000	1
ESSO PETRO	DYE WATER	1987	115	1
ESSO PETRO	PARTIALLY TREATED WASTE WATER	1986	10,614,910	1
FIBERGLAS	BLACK PROCESS WATER	1988	25	3
FIBERGLAS	RED PROCESS WATER	1986	80	2
FIBERGLAS	RED PROCESS WATER	1988	62.5	1
ESSO PETRO	STORM TANK WATER	1988	15,800	1
ESSO PETRO	UNTREATED WASTE WATER	1988	1,963,200	1

* Some spills are reported as having more than one contaminant. Each contaminant is cross-referenced according to an arbitrary number after the asterisk. For example, in 1989 Polysar has three spills containing TOC, of these three spills one also contained ammonia and benzene (i.e., all spills in Table 8.42 cross-referenced with '*5').

NOTES: -Means of ranges reported as value in this table.
-Spills reported as "mostly cleaned up" have not been used.
-NA - data not reported/available
-Weight calculated from reported volumes on the basis of the density of water (1 g/cm^3).
-Each entry represents total for year from that facility.

Complaints concerning raw and combined sewage (including CSOs) rose from zero in November-December 1986 to nine during the first six months of 1990 (Table 8.43). Marine City was cited as the location in approximately 55 percent of all sewage related complaints.

Chemical releases, contaminated effluents and fuel and gas spills potentially affecting the St. Clair River were also reported. Port Huron, Marysville and Sarnia, Ontario contributed approximately 34 percent, 21 percent and 16 percent, respectively, of all related calls.

8.3.3 Tributaries

The watershed of the St. Clair River region includes a geographic area of approximately 340,000 ha. Major tributary watersheds to the St. Clair River include Baby Creek and Talfourd Creek in Canada, and the Belle, Pine, and Black Rivers in Michigan (Nonpoint Source Workgroup 1987). A total of nearly 70 percent of the St. Clair River geographic area is agricultural, mostly characterized by intensive cropping.

Nonpoint sources of aquatic pollution associated with agricultural operations have traditionally included the additions of nutrient compounds (manure and commercial fertilizers), increases in particulate burdens from land erosion, and the inputs of fugitive pesticides and herbicides (Nonpoint Source Workgroup 1987). Each of the Ontario tributaries noted above, as well as the Cole Drain (included under point sources), also receive runoff contributions from industrial areas. Hence, industrial contaminants such as heavy metals, PCBs, chlorinated organic compounds and oil and grease characterize these tributaries.

8.3.3.1 Agricultural Additions

The use of commercial fertilizers and livestock manure as soil builders contributes to the pollution of adjacent aquatic resources by adding excessive burdens of bacteria, nitrogen, and phosphorus. On the U.S. side of the St. Clair River, commercial fertilizers are applied to approximately 78 percent of tillable land, while livestock wastes are added to 8 percent. The total quantity of phosphorus generated from manure has been estimated at 3,800 tonnes/year (4,188 tons/year) (Nonpoint Source Workgroup 1987). In Canada, croplands receive an estimated 3,800 tonnes (4,188 tons) of commercial fertilizer per year. This value

Table 8.43 Pollutants released to the St. Clair River and tributaries as reported through the Michigan Department of Natural Resources Pollution Emergency Alert System (PEAS), November 1986 through June 1990* (Selected Occurrences-complete list provided in Appendix 8.4).

Source	Substance Spilled*	Year	Amount**
	HYDROCARBONS		
DECO-Port Huron	Oil-PCB Containing Oil-non-PCB	1987	1 qt 1 qt
DECO-Marysville	Oil-non-PCB	1987	70 gal
Port Huron WWTP	Oil-non-PCB	1987	?
?-St. Clair Co.	Oil	1987	?
?-Algonac	Oil	1987	?
DECO-Marysville	Diesel Fuel	1987	30 gal.
Grand Trunk RR Ferry Dock	Oil-Hydraulic	1988	<50 gal.
?-Port Huron	Sheen	1988	?
Malcolm Marine-Port Huron	Oil-Hydraulic	1988	1 gal.
?-St. Clair	Oily White Sheen	1988	?
?-Port Huron	Gas-Flammable, Compressed	1988	?
Blue Water Oil Co.-Marine City	Oil-Fuel	1988	50-100 gal-Belle R. 50-100 gal-storm sewer
?-Port Huron	Oil-Fuel	1988	250 gal
?-St. Clair Co.	Oil Sheen	1988	?
?-Port Huron	Oil Slick	1988	?
?-Marine City	Oil	1988	?
?-St. Clair	Oil-non-PCB	1988	?
Dave Weeks-Orchard Beach	Oil-Hydraulic	1988	?
?-St. Clair Co.	Diesel Fuel	1988	100-150 gal
?-St. Clair Co.	Oil Slick	1988	?
DECO-East China Twp	Tar	1989	200 gal
Chrysler-Marysville	Oil Sheen	1989	?
DECO-Belle River	Tarry Substance	1989	?
?-St. Clair	Oil	1989	0.5 gal
?-Port Huron	Oil Sheen	1989	15'to 20' wide
?-Harsens Island	Oil	1989	?
Sassy Marina-Algonac	Oil-Fuel Fuel-Red/Blue Fuel-Diesel Oil-Gas	1989 1989 1989 1989	~5 gal ? >5 gal ?
?-Port Huron	Oil	1989	?
?-Marysville	Oil-Fuel	1989	?

Table 8.43 (cont'd)

Source	Substance Spilled*	Year	Amount**
DECO-St. Clair	Oil	1986	120 gal
	Oil-Lubricating		?
	Oil	1987	?
	Oil Sheen	1988	?
	Oil-Motor		2-3 gal
	Oil-Turbine	1989	~10 gal
	Oil-Turbine		5-10 gal
	Oil Sheen	1990	?
	Oil-Turbine		200-300 gal
	Oil		?
	Oil-Lubricating		1 gal
?-Marine City	Oil Sheen	1989	1 mi long
Dept. Public Works-St. Clair Co.(in Clay Twp)	Tar Spray	1989	?
Train Ferry-Port Huron	Oil-Hydraulic	1989	?
?-Algonac	Oil-Light	1990	?
Underground Tanks-Port Huron	Oil-Waste	1990	?
?-Marysville	Kerosine	1990	?
?-St. Clair Co.	Oil Slick	1990	<0.5 gal
?-Marysville	Oil Slick	1990	?
?-Algonac	Oil Globules	1990	?
	CHEMICALS - VARIOUS		
Chrysler-Marysville	Alkaline Stripper Sol'n	1987	~200 gal
F&W Barrel Recond.-Marysville	Barrel Washing	1988	?
American Tape-Marysville	Toluene	1988	250 gal
	Toluene		~100 gal
	Toluene		150 gal
	Latex	1989	~50 gal
	Latex		100 gal
?-Port Huron	Green Liquid	1988	?
?-St. Clair Co.	Chloroethylene (5 mg/L)	1988	?
SC Ammonia-Kimball Twp	Anhydrous Ammonia	1988	~800 lbs
E.B.Eddy-Port Huron	Paper Coating	1988	450 gal
	Caustic		?
Sandblasting-St. Clair Co.	Sand and Old Paint	1988	?
DECO-St. Clair	EDTA Solution	1989	24,157 lbs
	EDTA Solution		24,000 lbs
	Boiler Cleaner		500-1000 gal
Gibraltar Sprocket-Port Huron	Solvent	1989	?
Versatile Mfg-Marine City	Solvent	1989	100 gal
Exterminators-Algonac	Diazanon Spray	1989	?
Michigan Precision-Port Huron	Acid	1989	?
DeFour Regrigeration-Port Huron	Anti-Freeze	1990	?

Table 8.43 (cont'd)

Source	Substance Spilled*	Year	Amount**
EFFLUENT - VARIOUS			
E.B. Eddy-Port Huron	Process Water	1988	35,000 gal
	Paper Waste		3-5 mi long
	Process Water		23,000 gal
	pH Exceedence		45 min
	pH Exceedence		? (3 events)
	Process Water	1989	?
	Pulp and Paper Foam		?
	Paper Pulp, pH or White Substance		? (14 events)
Gibraltar Sprocket-Port Huron	Contact Cooling Water	1988	?
Diamond Crystal Salt-St. Clair Co.	pH = 9.7	1986	?
Chrysler-St. Clair Co.	Dark Coloured	1990	?
SEWAGE			
Port Huron WWTP	Raw Sewage	1987	?
?-Marine City	Raw Sewage	1987	?
Marine City WWTP	Raw Sewage	1988	336,000 gal
	Sewage-CSO	1989	? (3 events)
CSOs-Marine City	Sewage	1990	? (4 events)
?-Harsen's Island	Sewage	1988	?
E.B. Eddy-Port Huron	Sewage and Chlorine	1989	?
CSOs-Port Huron	Sewage	1989	?
?-Port Huron	Sewage	1990	?
CSOs-St. Clair	Sewage	1990	? - 9 CSOs
?-St. Clair Co.	Sewage	1990	?

* Substances included in the table are:

Chemicals	- Specific compounds and non-specific "chemical" complaints.
Effluent	- Untreated or partially treated wastewaters.
Fuel and Gas	- Diesel fuel and gas includes crude, cutting, fuel, hydraulic, lubricating, motor, turbine, waste, PCB and non-PCB oils. Oil slicks and oil sheens are also included.
Paper Wastes	- Paper filaments, pulps and other wastes.
Sewage	- Raw and combined sewage, including CSOs.

Other pollutants account for less than 30% of the total PEAS calls and are not included in this table.

** Substance amounts are approximations.

translates to 376 kg/ha (167.8 lb/acre). Analysis of soil fertility and crop requirements indicate that as much as two times more phosphorus fertilizer is being used than is required in both the U.S. and Canada. Livestock operations on the Canadian side of the river generate a further 6.3 tonnes/year (6.9 tons/year) of phosphorus, ultimately disposed of on farm land.

Johnson and Kauss (1991) analyzed water and suspended sediments from four Ontario tributaries to the St. Clair River during 1984-85. The tributaries included Perch Creek (which flows into Lake Huron near the head of the river), Talfourd Creek, Baby Creek and the Cole Drain. Pesticides monitored included atrazine, α-BHC, δ-BHC, dieldrin, α-endosulphan, p,p'DDE, p,p'DDD, p,p'DDT, endrin and methoxychlor. They noted that, while the presence of most pesticides is related to time of sampling versus the time of application, several pesticides which have been restricted in use, such as dieldrin and DDT, were found at detectable levels in whole water, suspended solids and bottom sediments of Talfourd Creek.

Dieldrin is the only pesticide which has been identified as exceeding water quality guidelines in the St. Clair River AOC (Chapter 6). The total loading of dieldrin from the four Ontario tributaries to the St. Clair River (1984-85), based on the instantaneous loadings determined by Johnson and Kauss (1991) is only 0.000118 kg/d. The loadings were calculated from the total instantaneous loading reported by the authors (1.36 μg/sec). This loading is very small and suggests that Michigan Surface Water Quality Guideline exceedences in the St. Clair River for this parameter is due to widespread contamination including sources from upstream of the Area of Concern. Johnson and Kauss (1991) concluded that dieldrin was ubiquitous, being detected in all tributaries studied (including tributaries to Lake St. Clair and the Detroit River). They also noted that it is an extremely stable compound which does not degrade quickly in soils and, hence, its presence may represent historical usage.

8.3.3.2 Industrial Contaminant Additions

Industrial organic compounds were detected primarily on suspended solids and were observed in bottom sediments at the tributary mouths. Concentrations of hexachlorobenzene (HCB), octachlorostyrene (OCS) and PCBs were observed in whole water, suspended solids and bottom sediments in Ontario tributaries. Several elevated levels were measured on suspended solids in the Cole Drain (HCB - 5.8 μg/g; OCS - 5.4 μg/g) and in Talfourd Creek (PCBs - 77.84 μg/g) (Nonpoint Source Workgroup 1987, Johnson and Kauss 1991). A comparison of instantaneous loadings of industrial organic compounds from selected tributaries revealed that these loads occasionally approached industrial point source loadings from the Dow 42 inch sewer (Johnson and Kauss 1991).

Table 8.44 provides instantaneous loading data for selected organic and inorganic parameters sampled in 1984-85. Table 8.45 identifies the relative loading contributions of the Ontario tributaries to the total loading of the St. Clair River for several parameters based on limited surveys conducted during 1984-85.

Of all the tributaries to the St. Clair River, Lake St. Clair and the Detroit River examined by Johnson and Kauss (1991), the Cole Drain had the most frequent detected concentrations of hexachloroethane, hexachlorobenzene and hexachlorobutadiene (43%, 89% and 57%, respectively).

These compounds were also detected in samples from Talfourd Creek and the Murphy Drain. There are no known sources of hexachlorobenzene or octachlorostyrene to Talfourd Creek and their occurrence, primarily on suspended solids, was identified by Johnson and Kauss (1991) as a concern. High PCB concentrations on suspended solids and bottom sediments were found in samples from Talfourd Creek. One of two bottom samples from this creek exceeded the Ontario Ministry of Environment dredging guideline (0.05 μg/g). Low concentrations (< 8 μg/L) of volatiles including chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, carbon tetrachloride, chlorodibromomethane and perchloroethylene were found from one survey (April 1984) in Talfourd Creek.

Table 8.44 Mean instantaneous loading values for selected inorganic (mg/sec) and organic (μg/sec) contaminants on suspended solids (S.S.) and in whole water at the outlet of Ontario tributaries during 1984-85 (Johnson and Kauss 1991).

Tributary	Cadmium		Chromium		Iron		Lead		Mercury		Nickel		Selenium		Zinc	
	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water
Perch Creek*	0.29	1.82	27.32	26.84	11777	13287	10.36	22.74	0.015	0.093	15.48	49.63	0.63	7.58	47.21	96.0
Talfourd Creek	0.08	0.85	12.47	12.86	2749	2335	4.71	11.58	0.035	0.078	4.2	14.26	0.17	2.74	21.79	43.17
Baby Creek	0.02	0.07	0.71	1.76	536	578	0.45	1.03	0.001	0.004	0.68	1.49	0.02	0.27	2.82	5.94
Cole Drain	0.02	0.36	1.47	2.43	485	373	1.03	2.43	0.006	0.019	0.82	4.14	0.01	0.45	6.17	12.33

Tributary	Hexachloroethane		Hexachlorobutadiene		Hexachlorobenzene		Octachlorostyrene		Total PCBs		Phenols	
	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water	S.S.	Water
Perch Creek	NA	0	NA	0	0	17.58	0	0	41.55	0	NA	13421
Talfourd Creek	NA	19.59	NA	4.72	5.68	24.82	1.01	3.03	812.26	0	NA	15339
Baby Creek	NA	0	NA	0.19	0.08	0	0.07	0	0.3	0	NA	662
Cole Drain	NA	61.65	NA	58.95	17.57	50.04	14.59	19.8	3.99	0	NA	16470

* Perch Creek flows into Lake Huron near the head of the St. Clair River.

Table 8.45 Magnitude of Ontario tributary loadings relative to total loadings to the St. Clair River (Johnson and Kauss 1991).

	Suspended Solids	**Dissolved Organic Carbon**	**Chloride**	**Phosphorus**	**Lead**	**Iron**	**Mercury**	**Zinc**	**HCB**	**OCS**	**Total PCBs**
Total Loading to River (mg/s)	54×10^6	9.8×10^6	50×10^6	55×10^3	18×10^5	8.1×10^5	75.3	11×10^3	8.9	2.1	3.0
Sum of Ont. Trib. Loads (mg/s)	0.13×10^6	0.02×10^6	0.21×10^6	0.95×10^3	15	0.03×10^5	0.1	61.4	0.075	0.023	0.82
Sum of Ont. Trib. Loads (kg/d)	11,232	1,728	18,144	18.08	1.296	259.2	0.0086	5.305	0.0065	0.00199	0.0709
Tributary inputs as percent of river	0.2	0.2	0.4	1.7	0.0008	0.4	0.1	0.6	0.8	1.1	27

Total Loading based on net change in loading between head and mouth.

Sum of Loadings based on 1984-85 sampling (using the largest of whole water or suspended particulates-associated loadings).

Table 8.45 indicates that the importance of Ontario tributary loadings relative to other sources (especially industrial point sources) is quite minimal. The only exception is PCBs for which tributaries contribute 27 percent of the total estimated loading. Talfourd Creek appears to be the primary contributor of tributary PCBs to the St. Clair River (Table 8.44).

8.3.4 Urban Runoff

8.3.4.1 Ontario Urban Runoff

Marsalek and Ng (1989) define urban runoff as "...a nonpoint source of pollution which is discharged into the receiving waters in two forms, either as stormwater discharges from storm sewers, or overflows from combined sewer systems." They calculated the loadings of 18 organic and inorganic parameters contributed to the St. Clair River via urban runoff and combined sewer overflows from the City of Sarnia.

Runoff loadings of each parameter except chloride were calculated for specific land use areas utilizing mean concentrations and runoff volume then summed for the area of each land use to estimate total loadings to the river. Chloride originates primarily from winter road salting and concentrations in runoff are highly variable.

Loadings were thus estimated from road salt usage records assuming that all salt is washed off by runoff (Marsalek and Ng 1989).

Annual runoff was estimated from mean annual precipitation using the STORM model. Total stormwater for Sarnia was calculated to be 6.7 X 10^6 m^3/year (1,742 X 10^6 U.S. gal/year). The total combined sewer overflow discharges were calculated to be 1.0 X 10^6 m^3/year (260 X 10^6 U.S. gal/year) (Marsalek and Ng 1989). CSO's service approximately 540 ha (1,334 acres) of the city and the collection area for urban runoff is 3,200 ha (7,904 acres).

Runoff was sampled at ten sites representing residential, commercial and industrial areas. CSOs were sampled at five sites including both overflow structures and the interceptor.

The results of the loading calculations for stormwater runoff and CSOs in Sarnia is presented in Table 8.46. Overflows exceeded stormwater loadings for only ammonia and total phosphorus whereas mercury loadings were comparable from both sources. In comparing these nonpoint loadings with municipal and industrial point sources (based on data taken from UGLCCS 1988), Marsalek and Ng (1989) concluded that for the majority of parameters, the point source loadings form the greatest portion of the total loadings. Based on the 1986 UGLCCS survey, Ontario and Michigan point sources contributed 90 percent or more of ammonia, phosphorus, cobalt, copper, lead, mercury, nickel, zinc, phenols, hexachlorobenzene, octachlorostyrene, cyanide, oil and grease, and chloride. Cadmium, iron, PCB and PAH loadings were approximately equal between nonpoint and point sources with stormwater runoff contributing 90 percent or more of the total nonpoint loadings (nonpoint sources included CSOs, stormwater runoff and tributaries).

Paul Theil Associates (1988) undertook an hydraulic analysis of the Sarnia CSOs as well as estimating fecal coliform counts and mass loadings for suspended solids, BOD, total phosphorus, cadmium, copper, lead and zinc. The study did not involve the collection of water quality data; all loading estimates, except for cadmium, were prepared from published concentration data representing U.S. cities (Woodward-Clyde Consultants 1986). Cadmium was estimated from concentration data representing the City of Toronto. The results of this study indicated that approximately 78 percent of the CSO volumes occur at three overflows located along the interceptor sewer system. These were identified as:

Table 8.46 Summary of annual loadings (as kg/day) in urban runoff from the Sarnia area (Marsalek and Ng 1987, 1989).

Parameter	Stormwater	Overflows	Total
Ammonia (N)	9.86 --	10.14 41.10*	20 50.96
Phosphorus	4.9 --	1.1 9.04	6.0 13.97
Chloride	3151 6301	87 172	3238 6473
Cadmium	0.01 0.11[a]	0.013 0.02[a]	0.023 0.13[a]
Cobalt	0 0.36[a]	0 0.05[a]	0 0.41[a]
Copper	0.89	0.37	1.26
Iron	112 --	7 22	119 134
Lead	5	0.8	5.8
Mercury	0.002 0.0022	0.0003 0.002	0.0023 0.0042
Nickel	0.39 0.60	0.014 0.06	0.404 0.66
Zinc	6.03	0.63	6.66
Oil & Grease	110 --	20 92	130 201
Total Phenols	0.31 --	0.02 0.07	0.33 0.37
Cyanide	0.05	0.008	0.058
Hexachlorobenzene	0.0022	0.0	0.0022
Octachlorostyrene	0.00004	0.000005	0.000045
PCBs (total)	0.0036 --	0.0003 0.0006	0.0039 0.0042
PAHs (17)	0.13 0.162	0.014 0.041	0.144 0.203

* Where applicable, both low and high loading estimates are given.
[a] Loadings calculated from data above the detection limit.

i) Exmouth at Front Street (overflow #8);
ii) Cromwell at Front Street (#6); and
iii) Devine at Christina Street (#7).

Mass loading comparisons between CSOs and stormwater runoff for the entire Sarnia area supported the findings of Marsalek and Ng (1989) that, for most contaminants, stormwater runoff loadings were greater than loads from CSOs. CSOs contributed only 2 to 7 percent of the loadings of all contaminants studied (with the exception of fecal coliform) from sources which also included the Sarnia WPCP and stormwater runoff. In comparing CSO, stormwater and WPCP loadings, the Sarnia WPCP contributed the largest loadings of BOD, total phosphorus, cadmium, copper and zinc; storm sewers were found to contribute the largest loadings of suspended solids and lead; and CSOs were responsible for 98 percent of the fecal coliform from within the study area (Paul Theil Associates 1988). For the entire City of Sarnia, it was estimated that CSOs account for 70 percent of the fecal coliform loading. Table 8.47 lists the loadings estimates for CSOs and stormwater for the entire City of Sarnia. The data in this table have been converted to daily loadings for comparative purposes, however, it should be noted that actual loadings occur in combination with rain events.

Table 8.47 Estimated contaminant loadings from CSOs and total City of Sarnia stormwater (Paul Theil Associates 1988). Loadings are in kg/day unless otherwise noted.

Parameter	CSO	Stormwater
Fecal Coliform[1]	1.04×10^{15}	4.26×10^{14}
Suspended Solids	186	2131
BOD	55	191
Total Phosphorus	2.5	7.1
Cadmium	0.0055	0.0273
Copper	0.1093	0.71
Lead	0.36	3.06
Zinc	0.36	3.39

[1] units are organisms per day.

8.3.4.2 Private Residential Sources in Ontario

Along the Ontario shore of the St. Clair River south of Sarnia, most of the population lives in serviced residential communities. Small municipal wastewater treatment facilities located in Moore Township (at Corunna and Courtright) and Sombra Township (at Sombra and Port Lambton) were built to treat sewage from the communities (Section 8.2.3.1). The Town of Mooretown is connected to the Courtright system.

Residences which are located between the serviced areas have private sewage systems which typically consist of a septic tank and tile field. There are approximately 250 unserviced private homes in Sombra Township and 120 in Moore Township.

Heavy clay soils along the river have proven to be unsuitable for the installation of in-ground tile fields. Failures of these systems have been confirmed by OMOE. These failures result in the discharge of partially treated sewage to the St. Clair River. These discharges are known to contain ammonia and bacteria, however, there are no data or estimates available regarding loadings to the river.

Most of the unserviced lots along the river or its tributaries are too small to permit the construction of the large private treatment systems now required by provincial regulation. Both the Township of Sombra and the Township of Moore are developing proposals to extend the sewers from existing serviced areas along the shore to collect the sewage from the unserviced homes. Sombra Township has received provisional Certificates of Approval from the province for the construction of the sewers and will be completing final design specifications in 1991. Construction is expected to start in 1992. Moore Township will be submitting applications in 1991 to the province for the proposed work.

Similar problems with private residential sewage treatment could be occurring in other areas which are adjacent to the river but are outside of provincial jurisdiction (e.g., Indian Reserves).

8.3.4.3 Michigan Urban Runoff

There are no data regarding the loadings of pollutants of concern from Michigan urban nonpoint sources. In 1986, the Michigan Department of Natural Resources completed a stormwater discharge inventory of the location and size of discharge pipes in the areas adjacent to the St. Clair River. Data relative to flows, water quality, contaminant concentration, annual discharge, or loadings were not provided.

The inventory reports that, on the Michigan shoreline, three urban areas have storm sewers which drain directly or indirectly into the St. Clair River. These urban areas and their stormwater discharges are: Port Huron with 10 storm sewers discharging directly into the St. Clair River, and 14 which discharge into the Black River; Marine City with three storm sewer outlets discharging into the Belle River; and Algonac, with two storm sewers discharging directly into the St. Clair River. The cities of Marysville and St. Clair, Michigan, have no stormwater discharges.

The federal *Clean Water Act*, as amended in February 1987, has language which specifically addresses the regulation of stormwater discharges. The Act specifies that these discharges will be regulated through the NPDES permit program. The stormwater program is currently under development and, thus, NPDES permits do not yet contain stormwater requirements.

8.3.4.4 Private Residential Sources in Michigan

Along the Michigan shore of the St. Clair River south of the City of Port Huron, there are several smaller communities that have municipal wastewater treatment facilities. These treatment plants generally service the area within the city limits and, in some cases, all or a portion of the surrounding townships as well. These wastewater treatment plants were discussed in detail in Section 8.2.3.2.

In those areas not serviced by a municipal wastewater treatment plant, individual residences have been required to install septic systems. In general, these systems consist of a septic tank and tile field. Permitting of these systems is done through the local County Health Department.

Due to heavy clay soil conditions and high groundwater levels along the river, some of these systems do not operate as designed. When a system fails, partially treated and/or raw sewage may be discharged to the river. Several complaints have been received about failed septic systems along the river and its tributaries. The St. Clair County Health Department and the MDNR are pursuing correction of these areas as they are discovered. The County Health Department has discontinued issuing septic system permits in those areas with failed systems. Extension of existing sewers is presently being pursued in areas for which problems have been identified.

8.3.5 Atmospheric Deposition

Direct atmospheric deposition of contaminants to the St. Clair River is likely to be negligible because of the relatively small surface area of the river. However, atmospheric deposition of contaminants to Lake Huron and onto the St. Clair River watershed may be significant. These loads are measured as part of the loading at the head of the river and at tributary mouths. Deposition to Lake Huron and the watershed is likely the mechanism responsible for the regular observation of common pesticides observed in the St. Clair River (IJC 1987). Such compounds as the metabolites of DDT, α-BHC, δ-BHC, and dieldrin are routinely reported in water samples from the St. Clair River, but the concentration of these contaminants does not change significantly over the length of the connecting channel. This fact suggests that there are no active sources along the St. Clair River (Chan et al. 1986, Chan and Kohli 1986).

Strachan and Eisenreich (1988) reviewed recent data to determine the role of atmospheric deposition of toxic chemicals to the Great Lakes. They concluded that both organic and inorganic contaminants are contributed to the lakes via rain, snow, atmospheric aerosols and vapour exchange. They also concluded that there are insufficient data available to reliably estimate the relative importance of the atmospheric deposition of most of these contaminants to the lakes or for the preparation of mass balances.

They estimated, utilizing mass balance methodology, that a significant portion of PCBs, lead and benzo-a-pyrene entering the Great Lakes was of atmospheric origin.

Drs. Eisenreich, Swackhamer and Long have received funding from the regional Great Lakes Protection Fund to conduct a three year study to provide an accurate assessment of the atmospheric deposition of fourteen critical pollutants to the Great Lakes. This will be accomplished through the collection and analysis of sediment cores in the Great Lakes as well as peat cores and sediments cores from remote lakes to establish historic loadings. Some remote area sampling sites will be located close to the St. Clair River. The levels in remote areas will be compared to those found in the Great Lakes sediments to estimate regional loadings from atmospheric deposition vs. loadings which include local direct discharge inputs. This project will be completed in, September 1993.

Air quality monitoring networks in vicinity of the St. Clair River AOC are currently operated by OMOE and Environment Canada. Ontario Hydro, the Lambton Industrial Society and private industry also operate ambient air monitors in the Sarnia area. To date, there are no contaminant loadings data available from these networks with which to compare to other sources.

8.3.6 Navigation

Ship traffic through the St. Clair River cause some minor sediment resuspension but should have little impact on the movement and effects of contaminants in the river. As noted in Chapter 6 (Section 6.3.2.6), sediments which form the bed of the river (bed load) are associated with less than one percent of measured contaminants as compared to those transported in water plus suspended sediments.

Periodic dredging is required in the lower channels of the river for navigation purposes. The material dredged from the Canadian channels is placed in a confined disposal facility (the Southeast Bend Cutoff Site, Seaway Island), when measured contaminant concentrations exceed open water disposal guidelines. Oil and grease and mercury are the contaminants which have been found to exceed guidelines in dredge spoils. When the concentrations of contaminants are found to be within guidelines the dredge spoils are disposed in open waters of Lake St. Clair.

Periodic U.S. shoal removal in the upper reaches of the river of a few hundred m^3 of sediment are disposed in Lake Huron. A few hundred thousand m^3 of sediments are removed by the U.S. in the lower reaches of the river approximately every three years. These materials are placed in the Dickinson Island Confined Disposal Facility.

Table 8.48 lists all ship-based spills reported to OMOE between 1986 and 1989. During this time small amounts of toluene and xylene were reported. The most commonly spilled substance from ships are hydrocarbon-based materials. Over the four year period the total amount of hydrocarbons reported as spilled from ships would be equal to a daily loading of about 1.43 kg/d.

In combination with the land-based spills reported in the previous section, the total daily loading equivalent of hydrocarbon fuels and lubricating materials is 5.55 kg/d. This compares to an oil and grease point source loading approximately equal to that contributed from ongoing point sources such as Esso Chemical (7.37 kg/d) or Shell Canada (8.15 kg/d). However, it should be noted that the nature of impacts due to spills are much different than those due to ongoing discharges. For example, acute biological effects due to spills may occur as a result of large loadings contributed at one time rather than chronic or sublethal effects related to smaller loadings contributed over a long period of time. The spills data have been converted to daily loadings simply to provide a sense of the relative magnitude of various sources.

In addition to spills, ships undergo ballast water changes and cleaning. These operations are discouraged in the St. Clair River but they are not currently regulated. Regulatory initiatives for the exchange of ballast waters in the Great Lakes are discussed in Chapter 4.

Ocean-going vessels entering the Great Lakes via the St. Lawrence Seaway have introduced foreign animal and plant life into the Great Lakes Ecosystem. The explosive spread of *Dreissena polymorpha* (the zebra mussel) could cause substantial damage to sport and commercial fisheries and tourism. Extensive damage to water intake and outlet pipes used by industry and municipalities is already occurring (OMNR 1990). An Environment Canada study of water samples taken from the ballast of more than 50 freighters entering the Great Lakes, revealed an abundance of foreign species. According to this 1981 report, 56 different species of exotic aquatic invertebrates as well as over 100 phytoplankton species were detected in the ballast water samples (R. Denning 1990, letter to M. Looby).

8.3.7 Contaminated Sediments

The sediments along the Canadian shore are significantly contaminated with a variety of chemicals (Rukavina 1986, Mudroch and Hill 1989, Carey et al. 1989). But compared to chemicals in water and suspended sediments, much less than one percent of the contaminants moving along the river are transported by bed sediment movement (Oliver 1988, Carey et al. 1989) (see Section 6.3.2.6). The total mass of contaminants such as hexachlorobenzene and octachlorostyrene in sediments on the Canadian side of the river is comparable to the annual loadings of these contaminants (Chan et al. 1986, Mudroch and Hill 1989). Unless a significant percent of this material is being desorbed each year, it is unlikely that contaminated sediments contribute significantly to the loading in the water column. However, because no measurements have been made, it is not possible to determine the on-going loadings of contaminants to water and biota in the river from in-place contaminated sediments.

Sediments can act as a source of contaminants to the biological community. Benthic organisms have been shown to accumulate contaminants from sediments in the river (Persaud et al. 1987). These organisms serve as a food source for higher trophic levels such as fish. Thus contaminated sediments can act as a source of higher body burdens of chemicals in biota in the system. Sediments from the Sarnia industrial area are lethal to *Hexagenia spp.*, *Hyallela spp.*, and fathead minnows (Environment Canada/OMOE 1986). Sediment toxicity and the accumulation of contaminants from sediments by biota are discussed in detail in Sections 6.3.2.7 and 6.3.3, respectively.

Table 8.48 Ship-based spills reported to OMOE for the period 1986 - 1989 (OMOE 1990b).

Substance Spilled	Year	Amount (kg)
HYDROCARBON MATERIALS		
DIESEL FUEL	1986	327.20
FUEL, BUNKER	1986	8.18
OIL, LUBE	1986	13.6
DIESEL FUEL	1987	166.90
OIL	1987	1.54
OIL, FUEL	1987	1.00
OIL, LUBE	1987	10.00
OIL, PRODUCT	1987	20.00
DIESEL	1988	10.00
DIESEL FUEL	1988	10.00
GASOLINE	1988	NA
NAPTHA SOLVENT	1988	60.00
OIL	1988	981.6
OIL SLOP	1988	90.00
OIL, GASOLINE	1988	NA
OIL, CRANKCASE	1988	7.00
DIESEL FUEL	1989	54.73
GASOLINE	1989	1.00
OIL SLUDGE	1989	13.64
OIL, GASOLINE	1989	11.00
OIL, HEAVY	1989	175.00
OIL, HYDRAULIC	1989	125.02
OTHER		
OIL, PALM	1989	327.20
TOLUENE	1987	7.50
XYLENE	1986	3.00
XYLENE	1987	trace

NOTE: Means of ranges reported as value in this table.
Spills reported as "mostly cleaned up" have not been used.
NA - data not reported/available

8.4 LOADINGS SUMMARY

Table 8.49 summarizes individual point sources and total nonpoint source loadings to the St. Clair River AOC (same as Table 8.1). This table includes the most recent loadings data presented in this chapter along with additional data from the 1986 UGLCCS survey (Point Source Workgroup 1988). The nonpoint source loadings are the same as reported by UGLCCS (1988) as more recent data have not been collected. The spills data are presented in Section 8.3.2 in a loadings format, however, these loadings are not directly correlative with those reported in Table 8.49 as the pollutants are often mixed with other chemicals. In addition, acute biological effects due to spills may be noted due to the large loadings contributed at one time rather than chronic or sublethal effects related to smaller loadings contributed over a long period of time. However, a sense of the magnitude of the loads and the relative importance of the sources reported in Sections 8.3.2 (Spills) and 8.3.6 (Navigation) can be obtained by comparing to individual point source dischargers.

In comparing the total point source and nonpoint source contributions, it is clear that, for the majority of contaminants, point sources contribute by far the largest loadings. However, the nonpoint source loadings should not be disregarded with respect to remedial strategies. Of particular concern are nonpoint source loadings of copper, iron, lead, mercury, nickel, cadmium, cobalt, PAHs, and PCBs. Nonpoint source loadings constitute more than ten percent of the total loadings for each of these parameters. In addition, nonpoint phosphorus and zinc contributions are close to ten percent of the total loadings. The actual contributions from nonpoint sources may be underestimated because data are not available from all nonpoint sources. Nonpoint sources of PCBs include both tributaries and urban runoff whereas urban runoff is likely the predominant nonpoint source for all other parameters noted above (see Section 8.5).

In comparison to the total loadings reported by UGLCCS (1988), the most notable changes since 1986 are reflected by the currently higher loadings of suspended solids, cadmium, cobalt, zinc and octachlorostyrene (Table 8.49). These higher loadings are in part due to the inclusion of more sources in the current report, particularly for suspended solids and total phosphorus. Increases in the metals reflect generally higher loadings from the Sarnia WPCP during 1987 than in 1986. Octachlorostyrene loadings are reflective of higher loadings from the Cole Drain reported in the MISA 1986/87 Pilot Site Investigation.

Improvements, i.e., reduced loadings since 1986, include BOD5 (particularly significant as there are more sources for which data are reported), phenols and volatiles. Reduced phenol loadings have occurred at most Ontario industries in both the petroleum refining and organic chemicals sectors. Reduced volatile loadings at Dow have contributed to the greatest reductions since 1986. The total volatile loading values reported for Ethyl and Polysar are based on the 1986 survey and it is not known whether this has changed. A significant portion of the volatile component for Polysar is benzene, whereas the major volatiles from Dow are 1,1-dichloroethane, 1,2-dichloroethane, 1,1,1-trichloroethane, carbon tetrachloride and tetrachloroethylene. The more recent data, while not currently available (MISA self-monitoring), may preempt the 1986/87 data. Given that abatement measures have continued to be instituted, further improvements likely have occurred.

Reductions in chlorinated organics from Dow, including hexachlorobenzene (>50%), octachlorostyrene (40%), tetrachloroethylene (62%) and hexachlorobutadiene (50%), have also been reported for the period 1986/87 to 1990 (Section 8.2.4.1.7). These revised loadings are not reflected in Table 8.49.

Figure 8.8 graphically illustrates the relative contributions of seven parameters from Ontario point sources, Michigan point sources and nonpoint sources in comparison to estimated loadings coming into the AOC from upstream sources (Lake Huron). The relative loadings (Figure 8.8) are based on the most current point source and nonpoint source loadings data available, as presented in Table 8.49. Lake Huron loading estimates are for 1984-85 and taken from Johnson and Kauss (1987). Not all parameters included in the current loadings summary (Table 8.49) were analyzed at the head of the St. Clair River by Johnson and

Table 8.49 Summary of major point and nonpoint source loadings (kg/d) to the St. Clair River 1986-1989 (also presented as Table 8.1).

Major Sources	Oil& Grease	Total Phosphorus	Ammonia Nitrogen	Suspended Solids	BOD5	Chloride	Copper	Iron	Lead	Mercury
PETROLEUM SECTOR										
Esso Petroleum	30.6	20.8	7.02	0	-	-	-	-	-	-
Shell Canada	8.15	9.9[b]	16.57	210.0	-	4,910[b]	-	-	-	-
Novacor Chemicals, Corunna	1.25	-	5.17	21.7	-	-	-	-	-	-
Suncor	45.6	-	17.45	219.0	-	-	-	-	-	-
ORGANIC CHEMICALS SECTOR										
Dow Chemical	285[b]	-	-	2413	-	283,820	6.24[b]	85.5	0.51	0.0163
Polysar/Novacor	3.68	15.8[b]	12.21	0	-	19,900	0.93[b]	-	0.08	0.0004
Ethyl Canada	-	-	-	-	-	29,800[c]	0.44[b]	19.1[b]	8.71[c]	0.0057[b]
DuPont Canada	-	-	-	-	-	-	0.45[b]	-	-	0.0019[b]
Esso Chemical	7.37	-	11.5	154.0	-	-	-	-	-	-
Novacor Chemicals, Mooretown	-	0.50[c]	-	21.9[c]	-	-	-	-	-	-
INORGANIC CHEMICALS SECTOR										
ICI Nitrogen Products	128[b]	3.91[c]	226.0[c]	4986[c]	-	-	-	209[b]	-	-
Fiberglas Canada	-	-	-	-	-	-	-	-	-	-
Lambton Generating Station	-	-	-	773	-	-	-	-	-	-
Cole Drain	1300[b]	-	-	3060.5[b]	-	11,400[b]	1.32[b]	23.5[b]	0.385	0.0022
ONTARIO MUNICIPAL SECTOR										
Pt. Edward WPCP	-	4.06	-	67.1	110.60	-	-	14.4[b]	-	-
Sarnia WPCP	244[b]	28.51	958	1299.7	2,127.71	6,200[b]	1.0	137.0[b]	4.5	0.005
Corunna WPCP	-	0.78	-	15.68	7.45	-	-	-	-	-
Courtright WPCP	-	0.26	-	8.26	3.84	-	-	-	-	-
Sombra Lagoon	-	0.02	-	15.56	0.42	-	-	-	-	-
Port Lambton Lagoon	-	0.08	-	17.82	0.67	-	-	-	-	-

Table 8.49 (Cont'd)

Major Sources	Oil& Grease	Total Phosphorus	Ammonia Nitrogen	Suspended Solids	BOD5	Chloride	Copper	Iron	Lead	Mercury
MICHIGAN MUNICIPAL SECTOR										
Port Huron WWTP	251[b]	25.0	-	250	-	-	0.64	-	-	-
Marysville WWTP	-	6.17	-	76	206	-	-	-	-	-
St. Clair WWTP	-	2.72	15.73	48.5	39.8	-	-	7.8[b]	0.23	-
Marine City WWTP	-	1.81	30.6[b]	34	82.1	-	-	12.4[b]	-	-
St. Clair-Algonac WWTP	-	2.91	181.0[b]	83.2	95.9	-	-	22.1[b]	-	ND
MICHIGAN INDUSTRIAL SECTOR										
James River KVP	-	-	-	209	250	-	-	-	-	-
E.B. Eddy Paper	294[b]	1.92	-	449	811	-	-	-	-	-
Akzo Salt	-	-	-	34	-	31,234	-	-	-	-
Detroit-Edison/St. Clair	76.5	-	-	393.3	-	-	-	-	-	-
Detroit-Edison/Belle	0.31	-	-	1.01	-	-	-	-	-	-
Detroit-Edison/Marysville	0.42	-	-	4.35	-	-	-	-	-	-
TOTAL POINT SOURCE LOADS	2,675.88	125.15	1,481.25	14,320.18	3,735.49	387,264	11.02	530.8	14.42	0.0315
TOTAL NONPOINT SOURCE LOADINGS	129.3-201.1	6.03-13.97	20.0-51.0	-	-	3,223-6,474	1.26	118-133	5.6	0.0023-0.004
TOTAL LOADINGS TO ST. CLAIR RIVER	2,805.18-2,876.98	131.18-139.12	1501.25-1532.25	14,320.18	3,735.49	390,487-393,738	12.28	648.8-663.8	20.02	0.0338-0.0355
TOTAL LOADINGS UGLCCS (1988)	3299-3371	95.9-103.9	1690-1721	9,400	7700	359,233-362,474	13.06	700-715	34.6	0.047-0.048

Table 8.49 (Cont'd)

Major Sources	Zinc	Nickel	Cadmium	Cobalt	Cyanide	Phenols	Volatiles	PAHs	PCBs	HCB	OCS
PETROLEUM SECTOR											
Esso Petroleum	0.49[c]	0.287[b]	-	-	-	0.13	0.75[c]	ND[b]	ND	-	-
Shell Canada	2.06[c]	0.519[b]	-	-	0.144[b]	0.099	4.04[c]	ND[b]	ND	-	-
Novacor Chemicals,Corunna	2.81[c]	-	-	-	-	0.023	0.00[c]	ND[b]	ND	-	-
Suncor	0.46[c]	-	-	-	-	0.188	0.23[c]	0.020[b]	ND	-	-
ORGANIC CHEMICALS SECTOR											
Dow Chemical	9.2[b]	0.644[b]	0.0041	-	ND[b]	1.3	31.41	ND[b]	0.0032[b]	0.012	0.0041
Polysar/Novacor	-	0.657[b]	0.0033	0.67[b]	0.16[b]	0.4	124.0[b]	0.163	ND[b]	ND	0.0002
Ethyl Canada	-	-	-	-	ND[b]	-	43.2[b]	0.045	ND[b]	-	-
DuPont Canada	-	0.385[b]	-	-	-	0.09	-	ND[b]	ND[b]	-	-
Esso Chemical	1.7[b]	-	-	-	-	0.032	-	ND[b]	ND[b]	-	-
Novacor Chemicals, Mooretown	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
INORGANIC CHEMICALS SECTOR											
ICI Nitrogen Products	2.4[b]	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Fiberglas Canada	-	-	-	-	-	0.015[c]	-	ND[b]	ND[b]	-	-
Lambton Generating Station	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Cole Drain	2.0[b]	0.243[b]	0.0465	-	0.54[b]	0.88[b]	1.61	0.172[b]	ND[b]	0.0088	0.0092
ONTARIO MUNICIPAL SECTOR											
Pt. Edward WPCP	-	-	-	-	-	1.69[b]	-	ND[b]	ND[b]	-	-
Sarnia WPCP	44.4	0.5	0.137	0.5	-	4.32[b]	0.742	0.118	0.009	-	-
Corunna WPCP	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Courtright WPCP	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Sombra Lagoon	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
Port Lambton Lagoon	-	-	-	-	-	-	-	ND[b]	ND[b]	-	-
MICHIGAN MUNICIPAL SECTOR											
Port Huron WWTP	2.42	0.23[b]	-	0.018[b]	0.31[b]	-	-	ND[b]	0.0019	-	ND[b]
Marysville WWTP	-	-	-	-	ND[b]	-	-	ND[b]	0.0002[b]	-	-
St. Clair WWTP	0.15	-	-	-	ND[b]	0.327[b]	-	ND[b]	-	-	ND[b]
Marine City WWTP	-	-	-	-	1.8[b,d]	-	-	ND[b]	0.0003[b]	-	-
St. Clair-Algonac WWTP	-	-	-	-	ND[b]	-	-	ND[b]	ND	-	-

Table 8.49 (Cont'd)

Major Sources	Zinc	Nickel	Cadmium	Cobalt	Cyanide	Phenols	Volatiles	PAHs	PCBs	HCB	OCS
MICHIGAN INDUSTRIAL SECTOR											
James River KVP	-	-	ND[b]	-	ND[b]	-	-	ND[b]	0.0003[b]	-	-
E.B. Eddy Paper	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Akzo Salt	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Detroit-Edison/St. Clair	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Detroit-Edison/Belle	-	-	ND[b]	-	ND[b]	-	-	ND[b]	-	-	-
Detroit-Edison/Marysville	-	-	-	-	-	-	-	-	-	-	-
TOTAL POINT SOURCE LOADS	68.09	3.465	0.1909	1.188	2.954	9.494	205.982	0.518	0.0149	0.0208	0.0135
TOTAL NONPOINT SOURCE LOADINGS	6.658	0.408-0.663	0.024-0.132	0.0-0.412	1.8	0.332-0.373	-	0.143-0.203	0.0038-0.0041	0.002	0.00004
TOTAL LOADINGS TO ST. CLAIR RIVER	74.75	3.873-4.128	0.2149-0.3229	1.188-1.600	4.754	9.826-9.867	205.982	0.661-0.721	0.0187-0.0190	0.0228	0.01354
TOTAL LOADINGS UGLCCS (1988)	51.6	4.85-5.03	0.169-0.31	0.86-1.27	5	12.53-12.57	254	0.478-0.538	0.0138-0.019	0.032	0.00494

- = data not available; ND = below detection limit; 0 denotes influent ≥ effluent.

a Data for this table have been taken from several sources representing a range in sampling periods and, hence, caution must be exercised in interpreting results. The table was generated by inserting the most recent loadings information into the loadings table prepared in UGLCCS (1988). Nonpoint source loadings reported as for UGLCCS (1988). Available information has been presented. The absence of data does not preclude the potential presence of a contaminant in listed discharges. Where loadings were not available, but contaminants are suspected to be present in a discharge, loadings may be underestimated.

Updated loadings sources and dates as follows:

Ontario WPCPs: - Tables 8.3 and 8.4 (1988 and 1987); remainder UGLCCS (1988)
Michigan: - calculated based on MDNR Discharge Monitoring Reports 1989); and UGLCCS 1986 data.
Petroleum Sector: - all but volatiles, PCBs and zinc from Table 8.30 (1988); zinc, PCBs and volatiles (from BTXE parameter) Table 8.17 (1988/89).
Organic Sector: - oil and grease, TP, NH_3, SS and phenols from Table 8.30 (1989); cadmium, mercury, HCB, OCS and total volatiles Table 8.31 (1986/87).
Inorganic Sector: - oil and grease, TP, NH_3, SS and phenols from Table 8.30 (1989); remainder UGLCCS (1986 data).

b Data from UGLCCS 1986 survey (Point Source Workgroup 1988).

c Data for Ontario point sources are net loads (i.e., outfall minus intake) with the exception of those marked by this footnote which are gross loadings; all Michigan point source data are gross loadings.

d This is based on the loadings calculated for the UGLCCS 1986 survey which found and elevated concentration of total cyanide (270 μg/L). This was the result of cyanide-containing waste water from an industrial source which was not properly pretreating its waste-water prior to discharge. Through the City's IPP program, the industry was brought into compliance with the ordinance limits and the concetrations in the WWTP final effluent have returned to normal. (Point Source Workgroup UGLCCS 1988). More recent cyanide loadings data are not available for this facility.

Kauss (1987). Suspended solids, phosphorus, chloride, mercury, hexachlorobenzene (HCB), octachlorostyrene (OCS) and PCB data are available for comparison. It should be noted, however, that differences in sampling and analytical methods as well as the dates of sampling for the various data sets make direct comparisons difficult. Also, the low concentrations (often near or at the detection level) of many of these of parameters at the head of the river, in combination with high flows, can result in significant overestimation or underestimation of the true loadings. Given these comments, it appears from Figure 8.8 that upstream loadings to the St. Clair River of mercury, suspended solids, phosphorus and chloride equal or greatly exceed the total loadings to the AOC from point and nonpoint sources within the AOC. Conversely, loadings of hexachlorobenzene, octachlorostyrene and PCBs from point and nonpoint sources within the AOC represent between 70 and 100 percent of all sources, including Lake Huron (Figure 8.8). Hexachlorobenzene and octachlorostyrene are products of the organic chemicals manufacturing industry on the Ontario side of the St. Clair River.

8.5 CAUSES OF IMPAIRMENTS

The use impairments noted in Chapter 7 for the St. Clair River are the result of chemical and physical impacts to the Area of Concern. Sources of contaminants were summarized in Section 8.4. In attempting to define remedial strategies for restoring beneficial uses and ultimately delisting the St. Clair River as an AOC, it is important to relate the impairments which have been identified to the causes of the impairments (i.e., the chemical or physical parameters) and ultimately to the sources of the parameters. At the present time it is not possible to establish direct cause-effect relationships for every impaired use.

In some cases, it is possible to directly relate an impairment to a chemical and, hence, the sources. The most obvious examples are the use impairments related to restrictions on dredging activities and fish consumption advisories. Although not identified as a use impairment by the IJC, exceedences of water quality guidelines for the protection of aquatic life is a concern and can be related to specific chemicals and sources.

Table 8.50 lists those parameters which were identified in Chapter 6 as exceeding guidelines (biota, sediment or water) and identifies corresponding sources and loadings based on data presented in this chapter. Table 8.51 identifies those point sources which are primary or secondary point source contributors of each parameter and the percentage of the total point source load contributed. This table is based on the loadings provided in Table 8.49. It should be noted that data are not available for some parameters at each source and, thus, Table 8.51 may overestimate the magnitude of the contribution from identified sources. Also, it is possible that, for any given parameter, other sources may displace either the primary or secondary contributor identified. These two tables provide the basis for the following discussion on the causes of use impairments.

8.5.1 Restrictions on Fish Consumption

Fish consumption advisories are currently in effect in Ontario due to mercury in walleye, white sucker, freshwater drum and yellow perch; and to PCBs in carp and gizzard shad. In Michigan, advisories due to mercury and PCBs are in place for freshwater drum, gizzard shad and carp.

According to Table 8.50, the predominant sources of mercury within the AOC are Ontario point sources (0.0315 kg/d) followed by the Ontario tributaries (Perch, Talfourd and Baby Creeks, 0.0064 kg/d). Predominant point sources of mercury are Dow Chemical (51.7% of all point sources) and Ethyl Canada (18.1%) (Table 8.51). In addition, 72 percent of the total mercury loading to the AOC is derived from upstream sources (Figure 8.8).

Figure 8.8

St. Clair River Remedial Action Plan

Relative loadings to the St. Clair River from point and non-point sources

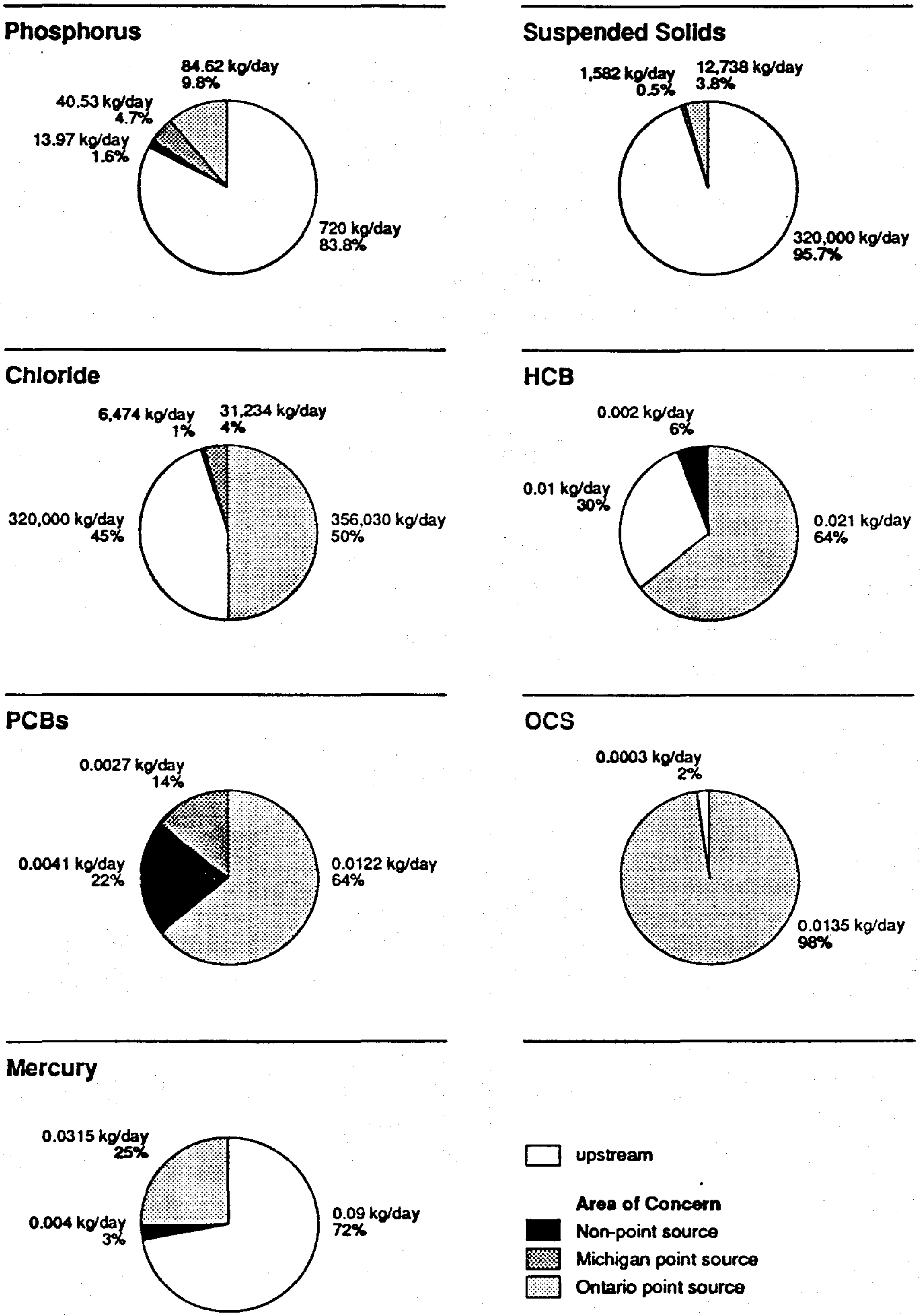


Table 8.50 Contaminants which have been identified as exceeding guidelines in the St. Clair River AOC in comparison to sources and known source loadings (in kg/d unless noted otherwise).

Parameter	Media in Which Guidelines Exceeded[1]	Ontario				Michigan
		Point Sources[2]	Tributaries[3]	CSOs[4]	Stormwater[4]	Point Sources[2]
Cadmium	w,s	0.1909	-	0.013-0.02	0.01-0.11	-
Chromium	s	11.46[a]	-	-	-	-
Copper	w,s	10.38	-	0.37	0.89	0.64
Iron	w,s	488.5	235.7	7-22	112	42.3
Lead	w,s	14.19	0.911	0.8	5.0	0.23
Manganese	s	-	-	-	-	-
Mercury	b,w,s	0.0315	0.0064	0.0003-0.002	0.002-0.0022	-
Nickel	s	3.235	-	0.014-0.06	0.39-0.60	0.23
Zinc	w,s	65.52	3.305	0.63	6.03	2.57
Oil & Grease	s	2,053.65	-	20-92	110	622.23
Total Kjeldahl Nitrogen	s	-	-	-	-	-
Total Phosphorus	w,s	84.62	82.08	1.1-9.04	4.9	40.53
Arsenic	s	-	-	-	-	-
Bacteria (organisms/day)[5]	w	-	1.04×10^{15}	4.25×10^{14}	-	-

Table 8.50 (cont'd)

Parameter	Media in Which Guidelines Exceeded[1]	Ontario				Michigan
		Point Sources[2]	Tributaries[3]	CSOs[4]	Stormwater[4]	Point Sources[2]
Chloride	w	356,030	6,744	87-172	3,151-6,301	31,234
Octachlorostyrene	b,w	0.0135	0.00199	0.000005	0.00004	-
Hexachlorobenzene	w,s	0.0208	0.0065	0.0	0.0022	-
Hexachlorobutadiene	w	0.183[a]	-	-	-	-
Tetrachloroethylene	w	3.11[a]	-	-	-	-
Carbon Tetrachloride	w	4.098[a]	-	-	-	-
Dieldrin	w	-	0.000118[b]	-	-	-
Total PAHs	s	0.518	-	0.014-0.041	0.13-0.162	ND
Total PCBs	b,w,s	0.0122	0.0709	0.0003-0.0006	0.0036	0.0027

- data not available or incomplete.
ND below detection.
1 b = biota, w = water, s = sediment.
2 From Table 8.49.
3 From Table 8.45 (data for Cole Drain in Table 8.49 subtracted from total tributary load shown in Table 8.45).
4 From Table 8.46.
5 From Table 8.47.
a From Table 8.31.
b From Text, Section 8.3.3.

Table 8.51 Primary and secondary point source contributors of contaminants to the St. Clair River AOC based on loadings data collected from 1986 through 1989[a] (facility loading and percent of total point source loading shown in brackets).

Contaminant	Primary Contributor	Secondary Contributor
Oil and Grease	Cole Drain (1,300 kg/d; 48.6%)	E.B.Eddy Paper (294 kg/d; 11.0%)[b]
Total Phosphorus	Sarnia WPCP (28.51 kg/d; 22.8%)	Port Huron WPCP (25 kg/d; 20.0%)[b]
Ammonia-N	Sarnia WPCP (958 kg/d; 64.7%)	ICI (226 kg/d; 15.3%)
Suspended Solids	ICI Nitrogen (4,986 kg/d); 34.8%)[b]	Cole Drain (3,060.5 kg/d; 21.5%)
Chloride	Dow Chemical (283,820 kg/d; 73.3%)	Akzo Salt (31,234; 8.1%)[b]
Copper	Dow Chemical (6.24 kg/d; 56.6%)	Cole Drain (1.32 kg/d; 12.0%)
Iron	ICI (209 kg/d; 39.4%)	Sarnia WPCP (137 kg/d; 25.8%)
Lead	Ethyl Canada (8.71 kg/d; 60.4%)[b]	Sarnia WPCP (4.5 kg/d; 31.2%)
Mercury	Dow Chemical (0.0163 kg/d; 51.7%)	Ethyl Canada (0.0057 kg/d; 18.1%)
Zinc	Sarnia WPCP (44.4 kg/d; 65.2%)	Dow Chemical (9.2 kg/d; 13.5%)
Nickel	Polysar/Novacor (0.657 kg/d; 19.0%)	Dow Chemical (0.0644 kg/d; 18.6%)
Cadmium	Sarnia WPCP (0.137 kg/d; 71.8%)	Cole Drain (0.137 kg/d; 24.4%)
Cobalt	Polysar/Novacor (0.67 kg/d; 56.4%)	Sarnia WPCP (0.5 kg/d; 42.1%)
Cyanide	Marine City WWTP (1.8 kg/d; 60.9%)[b,c]	Cole Drain (0.54 kg/d; 18.3%)
Total Phenols	Sarnia WPCP (4.32 kg/d; 45.0%)	Pt. Edward WPCP (1.69 kg/d; 17.6%)
Volatile Organics	Polysar/Novacor (124 kg/d; 60.2%)	Ethyl Canada (43.2 kg/d; 20.9%)
Total PAHs	Cole Drain (0.172 kg/d; 33.2%)	Polysar/Novacor (0.163 kg/d; 31.5%)
Total PCBs	Sarnia WPCP (0.009 kg/d; 60.4%)	Dow Chemical (0.0032 kg/d; 21.5%)
Hexachlorobenzene	Dow Chemical (0.012 kg/d; 57.7%)	Cole Drain (0.0088 kg/d; 42.3%)
Octachlorostyrene	Cole Drain (0.0092 kg/d; 68.1%)	Dow Chemical (0.0041 kg/d; 30.4%)

a Data for this table have been taken from several sources representing a range in sampling periods and, hence, caution must be exercised in interpreting results. The table was generated by inserting the most recent loadings information into the loadings table prepared in UGLCCS (1988). Nonpoint source loadings reported as for UGLCCS (1988). Available information has been presented. The absence of data does not preclude the potential presence of a contaminant in listed discharges. Where loadings were not available, but contaminants are suspected to be present in a discharge, loadings may be underestimated.

b Data for these facilities are gross loadings (i.e., no correction for intake loads).

c This is based on the loading calculated for the UGLCCS 1986 survey which found an elevated concentration of total cyanide (270 μg/L). This was the result of cyanide-containing wastewater from an industrial source which was not properly pretreating its wastewater prior to discharge. Through the City's IPP program, the industry was brought into compliance with the ordinance limits and the concentrations in the WWTP final effluent have returned to normal (Point Source Workgroup UGLCCS 1988). More recent cyanide loadings data are not available for this facility.

The predominant sources of PCBs within the AOC are Ontario tributaries (0.0709 kg/d) and Ontario point sources (0.0122 kg/d). The main point sources of PCBs are the Sarnia WPCP (60.4%) and Dow Chemical (21.5%). Although there are no upstream sources identified in the data used to construct Figure 8.8, concentrations of PCBs at the head of the river are known to be equivalent or higher than those in downstream reaches suggesting that upstream sources are likely important (Chan and Kohli 1987, Section 6.2).

8.5.2 Bird and Animal Deformities

Mouth part deformities occur in some chironomid species but there is no evidence of bird or other animal deformities or reproductive problems. Cause-effect linkages between chironomid deformities and chemicals have not been made. In the St. Clair River AOC, however, the occurrence of chironomid mouth part deformities and degraded chironomid communities (based on the density of chironomids) corresponded to the area offshore and immediately downstream of the Sarnia industrial area. This area was also found to have severely degraded to impaired benthic communities living in sediments contaminated with a variety of metals and organics (see Section 8.5.3).

8.5.3 Degradation of Benthos

Benthic community health is good on the Michigan side of the river but, as of 1985, was impaired along the Ontario shore for a distance of about 12 km (7.4 mi) beginning in the reach between the Sarnia WPCP and Dow Chemical and extending downstream past Stag Island to approximately Novacor Chemical (Canada) at Mooretown.

Benthic communities representing degraded and severely degraded conditions occurred in sediments which had the highest mean concentrations of copper, mercury, nickel, zinc, oil and grease, fibre, total organic carbon and total phosphorus. Sediments in this reach of the river also exceeded Ontario's biologically-based sediment guidelines for PAHs (lowest effect level) and hexachlorobenzene (lowest and severe effect levels).

Hexachlorobenzene, phosphorus and mercury have large upstream sources (30%, 21% and 72% of total loading, respectively) as well as having sources within the AOC (Figure 8.8). The predominant AOC sources of copper, mercury, nickel, zinc, oil and grease, PAHs and hexachlorobenzene are Ontario point sources (Table 8.50). Additional important sources include tributaries (mercury and hexachlorobenzene), stormwater (copper, nickel, zinc and PAHs) and Michigan point sources (oil and grease). The prominence of PAHs in stormwater is believed to reflect indirect atmospheric sources. Ontario and Michigan point sources and Ontario tributaries are all major sources of phosphorus to the AOC. Due to the flow pattern of the St. Clair River, it is unlikely that contaminant loads from Michigan sources contribute to degradation of benthos along the Ontario shoreline. The largest point sources of many of the contaminants associated with degraded benthic communities are the Sarnia WPCP, Dow Chemical, Polysar/Novacor and the Cole Drain (Table 8.51).

Spills from Ontario industrial sources, Michigan industrial sources and from shipping are also known to contribute large quantities of oil and other hydrocarbon products to the AOC. These are documented in Tables 8.42, 8.43 and 8.48. Facilities for which spills of these contaminants are most often recorded include Shell Canada, Esso Petroleum, Suncor, Polysar and Detroit Edison-St. Clair.

8.5.4 Restrictions on Dredging Activities

In Ontario, concentrations of copper, cadmium, chromium, iron, lead, mercury, nickel, zinc, PCBs, total phosphorus and oil and grease exceed OMOE guidelines for the open water disposal of dredged sediments and all but PCBs, cadmium and nickel are classified as heavily polluted by the U.S. EPA interim guidelines for the disposal of Great Lakes harbour sediments. Most exceedences occur along the Sarnia industrial waterfront, as far downstream as the Lambton Generating Station, and the mouths of Talfourd Creek, Baby Creek and the Murphy Drain.

In Michigan concentrations of total Kjeldahl nitrogen, oil and grease, arsenic, copper, chromium, iron, lead and manganese are considered moderately or heavily polluted by U.S. EPA guidelines and exceed OMOE disposal guidelines. Most exceedences occur at the mouths of the Black and Pine Rivers, adjacent or immediately downstream of Port Huron, Marine City and Algonac. There are currently no restrictions on dredging or disposal of dredged material from U.S. waters of the St. Clair River due to contaminants.

The aerial extent of sediment contamination is discussed in detail in Section 6.2.2 and summarized along with the year and magnitude of exceedences in Table 6.30. Contaminants which exceed OMOE or U.S. EPA dredge material disposal guidelines are specifically noted in Table 8.50 along with their major sources. Individual point sources of these parameters are identified in Tables 8.49 and 8.51. Due to the flow pattern of the river, sediment contamination is most likely the result of upstream sources and/or contaminant inputs from the side of the river where the contamination is found. Based on the limited amount of loadings data available for inputs from Michigan (no CSO, stormwater, tributary data) it is not possible to determine all sources or the largest source of sediment contaminants on the Michigan shoreline.

Sources of manganese and arsenic to the AOC have not been documented. Sediments found to exceed guidelines for these parameters have been found only offshore of Algonac and downstream of the mouth of the Pine River (manganese and arsenic) and the mouth of Baby Creek (manganese). Total Kjeldahl Nitrogen exceeds OMOE and U.S. EPA guidelines, however, this parameter is not directly measured at sources. Ammonia-nitrogen is a component of TKN and can be used to determine sources which may contribute to sediment contamination. Ontario and Michigan point sources contribute the largest loadings of ammonia (Table 8.50) with the largest point source loadings originating from the Sarnia WPCP (64.7%) and ICI Nitrogen (15.3%) based on available data (Table 8.51).

As noted in Section 8.5.3, spills from industrial sources and from ships are a major source of oil and other hydrocarbons to the AOC and these may contribute to sediment contamination. Ammonia is also a common component of industrial spills. The primary sources of spills containing ammonia include ICI Nitrogen and Polysar in Ontario (Table 8.42) and SC Ammonia in Kimbal Township, Michigan (Table 8.43).

8.5.5 Restrictions on Drinking Water Consumption or Taste and Odour Problems

Periodic closing of Water Filtration/Treatment Plants occur in both Michigan and Ontario as a result of chemical spills at upstream locations. The Health and Welfare Canada taste and odour aesthetic objective for ethylbenzene was exceeded at the Wallaceburg Water Treatment Plant during start-up following a spill in October 1990. Closures of the Wallaceburg WTP intakes based on level II responses are based on factors including taste and odour concerns.

Recent spills from Ontario and Michigan sources are identified in Tables 8.42 and 8.43. Closures of Ontario water treatment plants (at Wallaceburg and Walpole Island) were documented in Chapter 6 as a result of spills of Selexol from ICI Nitrogen (March 1989) and ethylbenzene from Dow (October 1990 and May 1991). Closures of the Marysville Water Filtration Plant have been documented due to spills from Polysar, Suncor, Esso Petroleum, Esso Chemical, Dow Chemical and the Port Huron WWTP.

Costs have also been incurred due to the distribution of bottled water during water treatment plant closures and extension of a drinking water pipeline from Lake Huron (Lambton WTP).

8.5.6 Beach Closings

There have been no beach closings in Michigan although all areas downstream of Michigan CSOs are identified as impaired areas due to the periodic discharge of raw or inadequately treated sewage. In Ontario, five beaches were closed as recently as the summer of 1990 for up to two months duration due to coliform bacterial levels which exceeded both Ontario and Michigan standards.

Loadings of bacteria from sources in the St. Clair River AOC have not been well documented. The bacteria data in Table 8.50 are estimates based on data extrapolated from areas outside the AOC. A recent study by Environment Canada and OMOE on loadings of bacteria from Sarnia CSOs and WPCPs and Ontario nearshore bacterial water quality will be available by mid-1991. Preliminary findings suggest that bacterial pollution is high and due primarily from human sources; wet weather bacterial concentrations are significantly higher than dry weather bacterial concentrations; and that elevated bacterial counts following rain events persist for several days (G. Johnson, OMOE, pers. com.).

Known sources of bacteria to the AOC include CSOs in Marine City, Port Huron and St. Clair (Table 8.43), Sarnia CSOs and stormwater, effluent from Ontario WPCPs, and other sources including agricultural runoff, private septic systems (Section 8.2.3), and some industrial outfalls. Each of the five Michigan WWTPs have fecal coliform limits in their NPDES permits (Section 8.2) and load estimates can be found in Appendix 8.2. No fecal coliform exceedences of these permit levels were identified.

8.5.7 Degradation of Aesthetics

Floating scums, oil slicks, spills and odours have been periodically reported. This impairment is a subjective category and it is difficult to quantify sources. Spills have been documented from Ontario industrial sources (Table 8.42), Michigan industrial, municipal and commercial sources (Table 8.42), and from ships (Table 8.47). Oil and other hydrocarbons are contaminants which are most frequently spilled from these sources. In addition, ongoing discharges of oil and grease occurs from Ontario point sources (2,054 kg/d) and Michigan point sources (622 kg/d) (Table 8.50). Wet weather periodic discharges occur from Sarnia CSOs (20 to 92 kg/d) and stormwater (110 kg/d). Of the point sources for which data are available, the largest contributors of oil and grease include the Cole Drain (1,300 kg/d) and E.B. Eddy Paper (294 kg/d) (Table 8.51).

8.5.8 Added Cost to Agriculture and Industry

Food processing industries in Ontario and a salt processing facility in Michigan have had to temporarily shut down their intakes due to upstream spills. Costs have also been incurred for proper disposal of contaminated sediment removed from the river for marine construction.

Spills which have resulted in food processing plant closures include the October 1990 ethylbenzene spill from Dow. Sources of spills resulting in WTP intake closures are discussed in Section 8.5.5. Sources of contaminants which exceed OMOE and U.S. EPA sediment dredge disposal guidelines are identified in Table 8.50 and discussed in Section 8.5.4.

8.5.9 Exceedences of Ambient Water Quality Criteria

Exceedences of Ontario PWQ Objectives, GLWQA Specific Objectives and Michigan's Water Quality Standards have occurred on occasion as follows:

iron - Ontario downstream of Sarnia and in Chenal Ecarte;
zinc - Walpole Island WTP intake (South Channel);
copper - Lambton (head of St. Clair River) and Walpole Island WTP (South Channel) intakes;
cadmium - near Dow and Suncor outfalls; and
hexachlorobenzene (PWQO and Michigan WQS) - Cole Drain downstream to Stag Island and the mouth of Talfourd Creek.

The provincial guideline for phosphorus was exceeded in raw water at the Wallaceburg WTP intake (Chenal Ecarte). In addition, Michigan WQS, were also exceeded as follows:

chloride - adjacent to Sarnia industrial waterfront;
fecal coliform bacteria - several Ontario beaches along length of river
mercury - offshore and immediately downstream of the Sarnia industrial area, in the Chenal Ecarte, and in raw water at the Lambton, Walpole and Wallaceburg WTP intakes;
lead - downstream of the mouth of the Black River;
total PCBs - entire river;
dieldrin - entire river;
carbon tetrachloride - offshore of Dow Chemical;
tetrachloroethylene - offshore of Dow Chemical; and
hexachlorobenzene - mouth of Bowens Creek and Chenal Ecarte.

The Canadian ambient water quality guideline for the protection of aquatic life due to hexachlorobutadiene was exceeded along the Ontario industrial waterfront immediately downstream of the Cole Drain (Table 6.23).

Each parameter which exceeded one or more of these criteria are specifically identified in Table 8.50 and their corresponding estimated loadings from Ontario and Michigan sources are indicated. For most parameters which exceeded water quality criteria relatively large loadings are derived from upstream sources (phosphorus and mercury) Ontario point sources (cadmium, copper, iron, lead, mercury, zinc, phosphorus, chloride, octachlorostyrene, hexachlorobenzene, hexachlorobutadiene, tetrachloroethylene and carbon tetrachloride). Ontario tributaries were the only known source of dieldrin, the largest source of total PCBs and also contributed relatively large loadings of phosphorus.

8.6 Summary and Data Gaps

Ontario industrial and municipal point sources contribute the largest loadings of most contaminants to the St. Clair River, in comparison to other sources located within the AOC. Upstream sources are known to contribute loadings of mercury, phosphorus, chloride and suspended solids equal to or greater than all sources within the AOC. Other sources located within the study area which, based on current data, are known to contribute relatively large loadings of certain parameters include Ontario tributaries and Sarnia stormwater.

In reviewing the loadings tables presented in this chapter, particularly the summary tables comparing among facilities, the reader should keep in mind that not all sources have been surveyed for all parameters. In many cases chemicals other than those regularly monitored likely occur, however, most probably occur at insignificant concentrations. There is a need to obtain more complete point source data to ensure that the full range of remedial options is explored.

The impairment status (Chapter 7) and loadings data represent a range of time periods. Impairments are based on ambient conditions occurring primarily in the 1985 to 1986 period. However, some data were collected in 1990 (spills and bacteria at Ontario and Michigan beaches) and some as early as 1983 (Michigan sediments). The year associated with each guideline exceedence is identified in Tables 6.23, 6.30 and 6.52.

The point source loadings presented in this chapter represent the period 1986 through 1989. Recent (1989) MISA data have been utilized for the petroleum sector and the most recent (1988 and 1989) data for those parameters which are regularly monitored at all municipal and industrial facilities in Ontario and Michigan have been utilized. However, loadings data for certain parameters (particularly toxic organics and metals) representing the organic and inorganic sector are required. These data also include a greater number of monitored parameters.

The most recent information available is utilized throughout this Stage 1 document. However, it should be noted that there are several important studies which have already been undertaken but the results of which were not available for use by the RAP Team. These include:

- the 1989/90 point source data for collected for the organic chemicals, inorganic chemicals and thermal generating sectors collected under Ontario's MISA Program;
- bacteria loadings from Sarnia CSOs and WPCPs as well as nearshore bacteria densities along the Sarnia waterfront from late 1990 which is currently being analyzed by Environment Canada and OMOE;
- the final results for ambient data on water, sediment and biota quality which were collected during 1990 are required to update impairment status;
- the 1991 fish contaminant monitoring data collected by OMOE and MDNR; and
- the results of the ongoing Health and Welfare Canada Great Lakes Health Effects Cohort Study of anglers and Native populations within the AOC.

The results of the 1990 ambient water, sediment and biota surveys, the bacteria study, and the most recent point source loadings collected under Ontario's MISA Program will be reported as updates to Stage 1 in the Stage 2 process.

In addition, the synthesis of existing data undertaken by the RAP Team has identified several significant data gaps which will need to be addressed as part of the Stage 2 RAP process. These are:

- additional information is required on ambient conditions within the AOC with which to make definitive conclusions regarding the impairment status for the tainting of fish and wildlife flavour, dynamics of wildlife populations, and fish tumours and other deformities;
- wildlife consumption guidelines for the protection of human health with consideration of potentially sensitive populations that rely on the consumption of wild meat;
- Great Lakes Basin wide assessments of the effects of contaminant body burdens on fish, wildlife and benthic organisms;
- loadings from Michigan tributaries, CSOs and stormwater; and
- more complete upstream loadings data in terms of the number of parameters and lower detection limits (particularly for PCBs).

Several data gaps have also been identified with regard to the need for information on biota within the Great Lakes Basin, in general. These are needed in order to fully assess impairments of beneficial uses associated with the consumption of wildlife by humans, the effect of chemical body burdens on fish and wildlife populations, and the effect of chemical body burdens on the degradation of benthos.

9.0 REFERENCES

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GLOSSARY, ACRONYMS AND UNITS OF MEASURE

MEASUREMENTS & UNITS

mg/L	=	milligram per liter	=	part per million (ppm)*
μg/L	=	microgram per liter	=	part per billion (ppb)*
ng/L	=	nanogram per liter (one trillionth part of a gram)	=	part per trillion (ppt)*
pg/L	=	picograms per litre	=	part per quadrillion (ppq)
μg/g	=	microgram per gram	=	part per million (ppm)
mg/kg	=	milligram per kilogram	=	part per million (ppm)
μg/kg	=	microgram per kilogram	=	part per billion (ppb)
ng/kg	=	nanogram per kilogram	=	part per trillion (ppt)
L/d	=	liter per day		
m^3/d	=	cubic meters per day		
mgd	=	millions of gallons per day		
cfs	=	cubic feet per second		
m^3/s	=	cubic meters per second		
kg/d	=	kilograms per day		
lbs/d	=	pounds per day		
kg/yr	=	kilograms per year		
t/yr	=	tonnes per year		
uS/cm	=	microsiemens per centimeter (conductivity)		

EQUIVALENT UNITS

meter	= m	1 m	= 3.281 feet
kilometer	= km	1 km	= 0.621 miles
gram	= g	1000 g	= 1 kg = 2.205 pounds
tonne	= t	1 t	= 2,205 pounds
liter (Can.)	= L	1 L	= 0.2642 gal (U.S.) = 0.2200 gal

CONVERSION TABLES

To Convert	Multiply By	To Obtain
acres	4.047×10^{-1}	hectares
acres	4.047×10^{3}	sq. meters
centimeters	3.937×10^{-1}	inches
centimeters	1.094×10^{-2}	yards
feet	3.048×10^{-1}	meters
gallons (Imp.)	1.20095	gallons (U.S.)
gallons (U.S.)	8.3267×10^{-1}	gallons (Imp.)
gallons (U.S.)	3.785	liters
gallons (Imp.)	4.542	liters
grams	1.0×10^{-3}	kilograms
grams	3.527×10^{-2}	ounces
grams	2.205×10^{3}	pounds
hectares	2.471	acres
inches	2.540	centimeters
kilograms	1.0×10^{3}	grams
kilograms	2.2046	pounds
kilograms	3.5274×10^{1}	ounces
kilometers	6.214×10^{-1}	miles
kilometers	1.0936×10^{3}	yards
kilometers	3.2808×10^{3}	feet
liters	2.642×10^{-1}	gallons (U.S.liquid)
liters	2.201×10^{-1}	gallons (Imp)
meters	3.281	feet
meters	6.214×10^{-4}	miles
meters	1.094	yards
miles	1.609	kilometers
milligrams/liter	1.0	parts/million
ounces	2.8349×10^{1}	grams
ounces (fluid)	2.957×10^{-2}	liters
parts/million	8.354	pounds/million gal.

To Convert	Multiply By	To Obtain
pounds	4.5359×10^{2}	grams
pounds	4.536×10^{-1}	kilograms
square feet	9.29×10^{-2}	sq. meters
square inches	6.452×10^{2}	sq millimeters
square kilometers	2.471×10^{2}	acres
square kilometers	1.076×10^{7}	sq. ft.
square kilometers	3.861×10^{-1}	sq. miles
square meters	2.471×10^{-4}	acres
temperature ^{o}C	$(^{o}C \times 9/5) + 32$	temperature ^{o}F
temperature ^{o}F	$(^{o}F - 32) \times 5/9$	temperature ^{o}C
yards	9.144×10^{1}	centimeters
yards	9.144×10^{-4}	kilometers
yards	9.144×10^{-1}	meters

ACRONYMS AND ABBREVIATIONS

ADI	Acceptable Daily Intake: The dose that is anticipated to be without risk to humans when taken daily. It is not assumed that this dose guarantees absolute safety. The determination of the ADI is often based on the application of laboratory animal toxicity data concerning chronic (long-term) doses to the environmental doses to which humans are exposed.
AOC(s)	Areas of Concern: Geographic locations recognized by the International Joint Commission where water, sediment or fish quality are degraded, and the objectives of the Great Lakes Water Quality Agreement of local environmental standards are not being achieved.
BaP	Benzo-a-Pyrene
BAT	Best Available Technology/Treatment
BATEA	Best Available Technology/Treatment Economically Achievable
BCF	Bioconcentration Factor; the ratio of the concentration of a particular substance in an organism to concentration in water.
BCT	Best Conventional Technology/Treatment.
BEJ	Best Engineering Judgement.
BHC	Benzene Hexachloride or Hexachlorocyclohexane. There are three isomers; alpha, beta, and gamma. Gamma-BHC is the insecticide lindane.
BOD	Biochemical Oxygen Demand: The amount of dissolved oxygen consumed during the decomposition of organic nutrients in water during a controlled period and temperature.
BMP	Best Management Practices
BPAC	Binational Public Advisory Committee
BPJ	Best Professional Judgement
BPT	Best Practical Treatment
CANUSLAK	(related to joint spill agreement)
CEPA	Canadian Environmental Protection Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COA	Canada-Ontario Agreement Respecting Water Quality in the Great Lakes.
COD	Chemical Oxygen Demand: The amount of oxygen required to oxidize completely by chemical reagents the oxidizable compounds in an environmental sample.
CofA	Certificate of Approval
CMR	Critical Materials Register

CSO — Combined Sewer Overflow; combined storm and sanitary sewer systems.

CWA — Clean Water Act

DCB — Dichlorobenzene

DDD — A natural breakdown product of DDT.

DDE — Dichlorodiphenyldichloroethylene. A natural breakdown product DDT.

DDT — Dichlorodiphenyltrichloroethane: A widely used, very persistent chlorinated pesticide (now banned from production and use in many countries).

DFO — Department of Fisheries and Oceans (Canada)

DMR — Discharge Monitoring Report

DOA — Department of Agriculture (Canada)

DOE/EC — Department of Environment/Environment Canada

DWQO — Drinking Water Quality Objective

EAA — Environmental Assessment Act (Ontario)

EARP — Federal (Canada) Environmental Assessment Review Process

EC-50 — Effective concentration of a substance producing a defined response in 50% of a test population. The higher the EC-50, the less effective the substance is because it requires more material to elicit the desired response.

EMPPL — Environmental Ontario Effluent Monitoring Priority Pollutants List

EMS — Enforcement Management System

EP — Extraction Procedure

EP/OR — Environmental Protection, Ontario Region, Environment Canada

EPA — United States Environmental Protection Agency
Environmental Protection Act (Ontario)

FDA — Food and Drug Administration

FPAC — Farm Pollution Advisory Committee

GLISP — Great Lakes International Surveillance Plan. It provides monitoring and surveillance guidance to U.S. and Canadian agencies responsible for implementing the provisions of the GLWQA that include general surveillance and research needs as well as monitoring for results of remedial actions.

GLWQA — Great Lakes Water Quality Agreement

HCB — Hexachlorobenzene

HCBD — Hexachlorobutadiene

HCE Hexachloroethane

HWC Health and Welfare Canada

IJC International Joint Commission: A binational organization established in 1909 by the Boundary Waters Treaty. Through the IJC, Canada and the United States cooperatively resolve problems along their common border, including water and air pollution, lake levels, power generation and other issues of mutual concern.

IMAC Interim Maximum Acceptable Concentration

IPP Industrial Pretreatment Program

LaMP Lakewide Management Plan

LC_{50} Lethal concentration (by volume) of a toxicant or effluent which is lethal to 50% of the test organism over a specified time period. The higher the LC_{50}, the less toxic it is because it takes more toxicant to elicit the same response.

LD_{50} Lethal dose which is lethal to 50% of the test organism over a specified time period. The higher the LD_{50}, the less toxic it is because it takes more toxicant to elicit the same response.

LIMA Lambton Industrial Meterological Alert

MAC Maximum Acceptable Concentration

MCL Maximum Contaminant Level

MCLG Maximum Contaminant Level Goal

MDNR Michigan Department of Natural Resources

MDPH Michigan Department of Public Health

MERA Michigan Environmental Response Act

MISA Municipal-Industrial Strategy for Abatement: The principal goal of this program is the virtual elimination of toxics discharged from point sources to surface waters in Ontario.

MGD Million Gallons Per Day

MSP Michigan State Police

NCP National Oil and Hazardous Substances Pollution Contingency Plan

NOAA National Oceanic and Atmospheric Administration

NPDES National Pollutant Discharge Elimination System; a permit system limiting municipal and industrial discharges, administered by U.S.EPA and the states.

NPDWR National Primary Drinking Water Regulation

NPS Nonpoint Source

NSPS New Source Performance Standards

NTU Nephelometric Turbidity Unit

OCS Octachlorostyrene

OMNR Ontario Ministry of Natural Resources

OMOE Ontario Ministry of the Environment/Environment Ontario

OWRA Ontario Water Resource Act

PAH Polynuclear Aromatic Hydrocarbons, also known as Polycyclic Aromatic Hydrocarbons or Polyaromatic Hydrocarbons. Aromatic Hydrocarbons composed of at least 2 fused benzene rings, many of which are potential or suspected carcinogens.

PBB Polybrominated biphenyl; used primarily as a fire retardant.

PCB Polychlorinated biphenyls; a class of persistent organic chemicals with a potential to bioaccumulate and suspected carcinogens; a family of chemically inert compounds, having the properties of low flammability and volatility and high electric insulation quality. Past applications include use as hydraulic fluids, heat exchange and dielectric fluids; plastisizers for plastics.

PCP Pollution Control Planning Program

PCPA Pest Control Products Act

PEAS Pollution Emergency Alert System

pH The negative power to the base 10 of the hydrogen ion concentration. A measure of acidity or alkalinity of water on a scale from 0 to 14; 7 is neutral; low numbers indicate acidic conditions, high numbers, alkaline.

PL Public Law

POTW Publicly Owned Treatment Works

PTS Persistent Toxic Substance: Any toxic substance with a half-life in water of greater than eight weeks.

PWQO Provincial Water Quality Objectives

QCB Pentachlorobenzene

RAP Remedial Action Plan

RCRA Resource Conservation and Recovery Act

SAC Ontario MOE Spills Action Centre

SDWA Safe Drinking Water Act

SEMCOG Southeast Michigan Council of Governments

SLC Screening Level Concentration

SPCC Spill Prevention and Control Countermeasure

TCDF	Tetrachlorodibenzofurans
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOTAL DDT	Sum of DDT isomers and metabolites
TP	Total Phosphorus
TTBEL	Treatment Technology-Based Effluent Limitation
UGLCCS	Upper Great Lakes Connecting Channels Study
U.S.EPA	United States Environmental Protection Agency
WHO	World Health Organization
WPCP	Water Pollution Control Plant
WQBEL	Water Quality Based Effluent Limits
WQS	Water Quality Standards
WRC	Water Resources Commission
WTP	Water Treatment Plant (for drinking water)
WWTP	Waste Water Treatment Plant

TERMINOLOGY

ABSORPTION — Penetration of one substance into the body of another.

ACCLIMATION — Physiological and behavioural adjustments of an organism in response to a change in environment. See also Adaptation.

ACCLIMATIZATION — Acclimation of a particular species over several generations in response to marked environmental changes.

ACCUMULATION — Storage and concentration of a chemical in tissue to an amount higher than intake of the chemical. May also apply to the storage and concentration of a chemical in aquatic sediments to levels above those that are present in the water column.

ACUTE — Involving a stimulus severe enough to rapidly induce a response; in bioassay tests, a response observed within 96 hours is typically considered an acute one.

ACUTE TOXICITY — Mortality that is produced within a short period of time, usually 24 to 96 hours.

ADAPTATION — Change in the structure forms or habits of an organism to better fit changed or existing environmental conditions. See also Acclimation.

ADSORPTION — The taking up of one substance at the surface of another.

AEROBIC — The condition associated with the presence of free oxygen in the environment.

ALGA(E) — Simple one celled or many celled micro-organisms, usually free floating, capable of carrying on photosynthesis in aquatic ecosystems.

ALGICIDE — A specific chemical highly toxic to algae. Algicides are often applied to water to control nuisance algal blooms.

ALKALINITY — A measurement of acid neutralization or buffering capability of a solution (See pH).

AMBIENT — Pertaining to the existing/surrounding environment and its components.

AMBIENT WATER — The water column or surface water as opposed to groundwaters or sediments.

AMPULES — A sealed glass container of a know concentration of a substance.

ANADROMOUS — Species which migrate from salt water to fresh water to breed.

ANAEROBE — An organism for whose life processes a complete or nearly complete absence of oxygen is essential.

ANOXIA — The absence of oxygen necessary for sustaining most life. In aquatic ecosystems this refers to the absence of dissolved oxygen in water.

ANTAGONISM — Reduction of the effect of one substance because of the introduction or presence of another substance; e.g. one substance may hinder, or counteract, the toxic influence of another. See also Synergism.

APPLICATION FACTOR A factor applied to a short-term or acute toxicity test to estimate a concentration of waste that would be safe in a receiving water.

AQUATIC Living in water.

ASSIMILATION The absorption, transfer and incorporation of substances (e.g. nutrients by an organism or ecosystem).

ASSIMILATIVE CAPACITY The ability of a waterbody to transform and/or incorporate substances (e.g. nutrients) by the ecosystem, such that the water quality does not degrade below a predetermined level.

BENTHIC Of or living on or in the bottom of a water body; benthic region, benthos.

BENTHOS Bottom dwelling organisms, the benthos comprise: 1) sessile animals such as sponges, some of the worms and many attached algae; 2) creeping forms such as snails and flatworms, and 3) burrowing forms which include most clams and worms, mayflies and midges.

BIOACCUMULATION Uptake and retention of environmental substances by an organism from both its environment (i.e. directly from the water) and its food.

BIOASSAY A determination of the concentration or dose of a given material necessary to affect a test organism under stated conditions.

BIOCONCENTRATION The ability of an organism to concentrate substances within its body at concentrations greater than in its surrounding environment or food.

BIOCONCENTRATION FACTOR The ratio of the measured residue within an organism compared to the residue of the substance in the ambient air, water or soil environment of the organism.

BIOLOGICAL MAGNIFICATION The concentration of a chemical up the food chain.

BIOMASS Total dry weight of all organisms in a given area or volume.

BIOMONITORING The use of organisms to test the toxic effects of substances in effluent discharges as well as the chronic toxicity of low level pollutants in the ambient aquatic environment.

BIOTA Species of all the plants and animals occurring within a certain area or region.

CARCINOGEN Cancer causing chemicals or substances.

CHIRONOMID Any of a family of midges that lack piercing mouth parts.

CHRONIC Involving a stimulus that lingers or continues for a long period of time, often one/tenth of the life span or more.

CHRONIC TOXICITY Toxicity marked by a long duration, that produces an adverse effect on organisms. The end result of chronic toxicity can be death although the usual effects are sublethal; e.g. inhibits reproduction or growth. These effects are reflected by changes in the productivity and population structure of the community. See also Acute Toxicity.

COMMUNITY Group of populations of plants and animals in a given place; ecological unit used in a broad sense to include groups of various sizes and degrees of integration.

CONGENER A member of the same taxonomic genus as another plant or animal: Also a different configuration or mixture of a specific chemical usually having radical groups attached in numerous potential locations.

CONTAMINANT A substance foreign to a natural system or present at unnatural concentrations.

CONTAMINATION The introduction of pathogenic or undesirable micro-organisms, toxic and other deleterious substances which renders potable water, air, soils, or biota unfit for use.

CONTROL ORDER/DIRECTOR'S ORDER/PROVINCIAL OFFICER'S REQUIREMENT AND DIRECTION Legally enforceable orders in Ontario.

CONVENTIONAL POLLUTANT A term which includes nutrients, substances which pollutant consume oxygen upon decomposition, materials which produce an oily sludge deposit, and bacteria. Conventional pollutants include phosphorous, nitrogen, chemical oxygen demand, biochemical oxygen demand, oil and grease, volatile solids, and total and fecal coliform, chlorides, etc.

CRITERIA Numerical limits of pollutants established to protect specific water uses.

CRITERION, WATER QUALITY A designated concentration of a constituent based on scientific judgments, that, when not exceeded will protect an organism, a community of organisms, or a prescribed water use with an adequate degree of safety.

CRITICAL LEVEL See Threshold.

CRITICAL RANGE In bioassays the range of magnitude of any factor between the maximum level of concentration at which no organisms responds (frequently mortality) to the minimum level or concentration at which all organisms respond under a given set of conditions.

CUMULATIVE Brought about or increased in strength by successive additions.

CUMULATIVE ACTION Increasingly severe effects due to either storage or concentration of a substance within the organism.

DENSITY Number of individuals in relation to the space.

DETRITUS A product of disintegration, defecation, destruction, or wearing away.

DIATOM Any of a class of minute planktonic unicellular or colonial algae with silicified skeletons.

DIOXIN A group of approximately 75 chemicals of the chlorinated dibenzodioxin family, including 2, 3, 7, 8 - tetrachlorodibenzo-para-dioxin (2,3,7,8 - TCDD) which is generally considered the most toxic form.

DISSOLVED OXYGEN The amount of oxygen dissolved in water.

DRAINAGE BASIN A waterway and the land area drained by it.

DREDGE SPOILS The material removed from the river, lake, or harbour bottom during dredging operations.

DREDGING GUIDELINES Procedural directions designed to minimize the adverse effects of shoreline and underwater excavation with primary emphasis on the concentrations of toxic materials within the dredge spoils.

ECOSYSTEM The interacting complex of living organisms and their non-living environment; the biotic community and its abiotic environment.

EFFLUENT Contaminated waters discharged from facilities to either wastewater sewers or to surface waters.

ENVIRONMENT All the biotic and abiotic factors that actually affect an individual organism at any point in its life cycle.

EPHEMERAL A plant that grows, flowers, and dies in a few days.

EPHEMERA Invertebrates (mayflies) that live as adults only a very short time.

EPILIMNION The warm, upper layer of water in a lake that occurs during summer stratification.

EROSION The wearing away and transportation of soils, rocks and dissolved minerals from the land surface, shorelines, or river bottom by rainfall, running water, wave and current action.

EUTROPHICATION The process of nutrient enrichment that causes high productivity and biomass in an aquatic ecosystem. Eutrophication can be a natural process so it can be a cultural process accelerated by an increase of nutrient loading to a waterbody by human activity.

EXOTIC SPECIES Species that are not native to the Great Lakes and have been intentionally or inadvertently inroduced into the system.

FACULTATIVE Exhibiting a broad lifestyle which allows it to survive under a broad range of environmental conditions.

FOODCHAIN The process by which organisms in higher trophic levels gain energy by consuming organisms at lower trophic levels; the dependence for food of organisms upon others in a series, beginning with plants and ending with the largest carnivores.

GOAL An aim or objective towards which to strive; it may represent an ideal condition that is difficult, if not impossible to attain economically.

GREAT LAKES BASIN ECOSYSTEM The interacting components of air, land, water and living organisms, including man, within the drainage basin of the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States (from Article 1 of the 1978 GLWQ Agreement).

GREAT LAKES WATER QUALITY AGREEMENT (GLWQA) A joint agreement between Canada and the United States which commits the two countries to develop and implement a plan to restore and maintain the many desirable uses of the waters in the Great Lakes Basin. Originally signed in 1978, the Agreement was amended in 1987.

GROSS LOADINGS The mass of any given contaminant in the effluent from a facility over a stated period of time (usually expressed as kg/d) including sources from within a facility as well as upstream sources delivered via the facility's influent.

GROUNDWATER Water entrained and flowing below the surface which may supply water to wells and springs.

GUIDELINES Any suggestion or rule that guides or directs; i.e. suggested criteria for programs or effluent limitations.

HALF-LIFE The period of time in which a substance loses half of its active characteristics (used specifically in radiological work); the amount of time required for the concentration of a pollutant to decrease to half of the original value through natural decay or decomposition.

HAZARDOUS SUBSTANCES Chemicals considered to be a threat to man in the environment, including substances which (individually or in combination with other substances) can cause death, disease (including cancer), behavioural abnormalities, genetic mutations, physiological malfunctions or physical deformities.

HYDROLOGIC CYCLE The natural cycle of water on earth, including precipitation as rain and snow, runoff from land, storage in groundwaters, lakes, streams, and oceans, and evaporation and transpiration (from plants) into the atmosphere to complete the cycle.

HYPOLIMNION The cold, dense, lower layer of water in a lake that occurs during summer stratification.

ICHTHYOLOGY A branch of zoology that deals with fishes.

INCIPIENT LC_{50} The level of the toxicant which is lethal for 50% of individuals exposed for periods sufficiently long that acute lethal action has ceased. Synonymous with lethal threshold concentration.

INCIPIENT LETHAL LEVEL That concentration of a contaminant beyond which an organism could no longer survive for an indefinite period of time.

INSECTICIDE Substances or a mixture of substances intended to prevent, destroy or repel insects.

LACUSTRINE Formed in, or growing in lakes.

LEACHATE Materials dissolved or suspended in water that percolate through solids such as soils, solid wastes and rock layers.

LETHAL Involving a stimulus or effect directly causing death.

LIPOPHILIC Having an affinity for fats or other lipids.

LITTORAL Productive shallow water zone of lakes, rivers or the seas, with light penetration to the bottom; often occupied by rooted aquatic plants.

LOADINGS Total mass of pollutant to a water body over a specified time; e.g. tonnes per year of phosphorus.

MACROPHYTE A member of the macroscopic plant life (i.e. larger than algae) especially of a body of water.

MACROZOOBENTHOS The distribution of macrozoobenthos in an aquatic ecosystem is often used as an index of the impacts of contamination on the system.

MALIGNANT Resistent to treatment, occurring in severe form and frequently fatal.

MASS BALANCE An approach to evaluating the sources, transport and fate of contaminants entering a water system, as well as their effects on water quality. In a mass balance budget, the amounts of a contaminant entering the system less the amount leaving the system. If inputs exceed outputs, pollutants are accumulating and contaminant levels are rising. Once a mass balance budget has been established for a pollutant of concern, the long-term effects on water quality can be simulated by mathematical modelling and priorities can be set for research and remedial action.

MUTAGEN Any substance or effect which alters genetic characteristics or produces an inheritable change in the genetic material.

MUTAGENICITY The ability of a substance to induce a detectable change in genetic material which can be transmitted to progeny, or from one cell generation to another within an individual.

NET LOADINGS The mass of any given contaminant in the effluent from a facility over a stated period of time (usually expressed as kg/d) minus the mass of the contaminant in the facility's influent.

NONPOINT SOURCE Source of pollution in which pollutants are discharged over a widespread area or from a number of small inputs rather than from distinct, identifiable sources.

NUTRIENT A chemical that is an essential raw material for the growth and development of organisms.

ORGANOCHLORINE Chlorinated hydrocarbon pesticides.

PATHOGEN A disease causing agent such as bacteria, viruses, and parasites.

PERIPHYTON Organisms that live attached to underwater surfaces.

PERSISTENT TOXIC SUBSTANCES Any toxic substance with a half-life in water and greater than eight weeks.

PESTICIDE Any substance used to kill plants, insects, algae, fungi or other organisms; includes herbicides, insecticides, algicides, fungicides.

PHENOLICS Any of a number of compounds with the basic structure of phenol but with substitutions made onto this structure. Phenolics are produced during the coking of coal, the distillation of wood, the operation of gas works and oil refineries, from human and animal wastes, and the microbiological decomposition of organic matter.

PHOTOSYNTHESIS A process occurring in the cells of green plants and some micro-organisms in which solar energy is transformed into stored chemical energy.

PHYTOPHAGOUS Feeding on plants.

PHYTOPLANKTON Minute, microscopic aquatic vegetative life; plant portion of the plankton; the plant community in marine and freshwater situations which floats free in the water and contains many species of algae and diatoms.

PISCIVOROUS Fish-eating

POINT SOURCE A source of pollution that is distinct and identifiable, such as an outfall pipe from an industrial plant.

POLLUTION (WATER) Anything causing or inducing objectionable conditions in any watercourse and affecting adversely the environment and use or uses to which the water thereof may be put.

POTABLE WATER Water suitable, on the basis of both health and aesthetic considerations, for drinking or cooking purposes.

PRECAMBRIAN The earliest eon of geological history.

PRIMARY TREATMENT Mechanical removal of floating or settable solids from wastewater.

PUBLIC Any person, group, or organization.

RADIONUCLIDE A radioactive material.

RAPTORS Birds of prey.

RAW WATER Surface or groundwater that is available as a source of drinking water, but has not received any treatment.

RESUSPENSION (of sediment) The remixing of sediment particles and pollutants back into the water by storms, currents, organisms and human activities such as dredging.

RIPARIAN Living or located on the bank of a natural watercourse.

SCAUP A diving duck.

SECONDARY TREATMENT Primary treatment plus bacterial action to remove organic parts of the waste.

SEDIMENT The fines or soils on the bottom of the river or lake.

SEICHE An oscillation in water level from one end of a lake to another due to wind or atmospheric pressure. Most dramatic after an intense but local weather disturbance passes over one end of a large lake.

SELENIUM A nonmetallic element that chemically resembles sulfur and is obtained chiefly as a by-product in copper refining, and occurs in allotropic forms of which a gray stable form varies in electrical conductivity with the intensity of its illumination and is used in electronic devices.

SESSILE An animal that is attached to an object or is fixed in place (e.g. barnacles).

SIGMOID CURVE S-shaped curve (e.g. the logistic curve)

SLUDGE The solids removed from waste treatment facilities.

SOLUBILITY Capability of being dissolved.

STABILITY Absence of fluctuations in populations; ability to withstand perturbations without large changes in composition.

STRATIFICATION (or layering) The tendency in deep lakes for distinct layers of water to form as a result of vertical change in temperature and therefore, in the density of water.

SUBACUTE Involving a stimulus below the level that causes death.

SUBCHRONIC Effects from short-term multiple dosage or exposure; usually means exposure for less than three months.

SUB-LETHAL Involving a stimulus below the level that causes death.

SUSPENDED SEDIMENTS Particulate matter suspended in water.

SYNERGISM The joint action of two or more substances is greater than the sum of the action of each of the individual substances. The improvement in performance is achieved because two agents are working together. See also Antagonism.

SYNERGISTIC Interactions of two or more substances or organisms producing a result such that the total effect is greater than the sum of the individual effects.

SYNTHESIS The production of a substance by the union of elements or simpler compounds.

TAXA A group of similar organisms.

TAXONOMICALLY To identify an organism by its structure.

TERATOGEN A substance that increases the incidence of birth defects.

TERATOGENICITY The ability of a substance to produce irreversible birth defects, or anatomical or functional disorders as a result of an effect on the developing embryo.

THERMOCLINE A layer of water in lakes separating cool hypolimnion (lower layer) from the warm epilimnion (surface layer).

THRESHOLD The chemical concentration or dose that must be reached before a given reaction occurs.

TOXIC SUBSTANCE As defined in the Great Lakes Agreement, and substance that adversely affects the health or well being of any living organism.

TOXICITY Quality, state or degree of the harmful effect resulting from alteration of an environmental factor.

TRANSLOCATION Movement of chemicals within a plant or animal; usually refers to systemic herbicides and insecticides that are moved from the point of contact on the plant to other regions of the plant.

TROPHIC ACCUMULATION Passing of a substance through a food chain such that each organism retains all or a portion of the amount in its food and eventually acquires a higher concentration in its flesh than in its food. See also Biological Magnification.

TROPHIC LEVEL Functional classification of organisms in a community according to feeding relationships; the first trophic level includes green plants, the second level includes herbivores; etc.

TROPHIC STATUS A measure of the biological productivity in a body of water. Aquatic ecosystems are characterized as oligotrophic (low productivity), mesotrophic (medium productivity) or eutrophic (high productivity).

TUBIFICID Of aquatic oligochaete or sludge worms which is tolerant to organically enriched waters.

TURBIDITY Deficient in clarity of water.

WATER QUALITY OBJECTIVES Under the Great Lakes Water Quality Agreement, goals set by the Governments of the United States Agreement, goals set by the Governments of the United States and Canada for protection of the uses of the Great Lakes.

WATER QUALITY STANDARD A criterion or objective for a specific water use standard that is incorporated into enforceable regulations.

WIND SET-UP A local rise in water levels caused by winds pushing water to one side of a lake. (See Seiche)